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GSO 218 (1994) (English): INDUSTRIAL SAFETY AND
HEALTH REGULATIONS - ELECTRICAL - PART 2: LOW
VOLTAGE



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**INDUSTRIAL SAFETY AND HEALTH
REGULATIONS – ELECTRICAL –
PART 2: LOW VOLTAGE**

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INDUSTRIAL SAFETY AND HEALTH REGULATIONS – ELECTRICAL – PART 2: LOW VOLTAGE

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**INDUSTRIAL SAFETY AND HEALTH
REGULATIONS – ELECTRICAL –
PART 2: LOW VOLTAGE**

1- SCOPE

This section applies to all electrical installations, and electrical equipment operating or intended to operate on systems of 600 volts or less between conductors.

2- EXECUTION OF WORK**2.1 General**

All electrical work, installation, and wire capacities shall be in accordance with the pertinent provisions of Section 7.0, unless otherwise modified by regulations of this item 2.

2.2 Applicability

These regulations apply only to electrical installations used on the job site, both temporary and permanent. For high voltage power distribution and transmission lines, see item 13.

2.3 Protection of Employees

No employer shall permit an employee to work in such proximity to any part of an electric power circuit that he may contact the same in the course of his work unless the employee is protected against electric shock by de-energizing the circuit and grounding it or by guarding it by effective insulation or other means. In work areas where the exact location of underground electric power lines is unknown, workmen using jack-hammers, bars, or other hand tools which may contact a line shall be provided with insulated protective gloves. Before work is begun the employer shall ascertain by inquiry or direct observation, or by instruments, whether any part of an electric power circuit, exposed or concealed, is so located that the performance of the work may bring any person, tool, or machine into physical or electrical contact therewith. The employer shall post and maintain proper warning signs where such a circuit exists. He shall advise his employees of the location of such lines, the hazards involved and the protective measures to be taken.

2.4 Passageways and Open Spaces

Suitable barriers or other means shall be provided to ensure that workspace for electrical equipment will not be used as a passageway during periods when energized parts of electrical equipment are exposed.

2.5 Lockout and Tagging of Circuits

2.5.1 Equipment or circuits that are de-energized shall be rendered inoperative and have tags attached at all points where such equipment or circuits can be energized. Whenever practical, enclosures or the operating levers at such points shall be padlocked so the circuit can not be energized without removing the lock, and the

key shall remain in the possession of the work crew.

- 2.5.2 Controls that are to be deactivated during the course of work on energized or de-energized equipment or circuits shall be tagged.

- 2.5.3 Tags shall be placed to identify plainly the equipment or circuits being worked on.

2.6 Ground-Fault Personnel Protection

- 2.6.1 To protect employees on construction sites, the employer shall use either or both ground-fault circuit interrupters as specified in item 2.6.2 or an assured equipment grounding conductor program as specified in item 2.6.3. These requirements are in addition to any other requirements for equipment grounding conductors.

- 2.6.2 All 127 volt, AC, single-phase, 20 ampere or less receptacle outlets, on construction sites, which are not a part of the permanent wiring of the building or structure and which are in use by employees, shall have approved ground-fault circuit interrupters for personnel protection. Receptacles on a 2-wire, single-phase portable or vehicle-mounted generator rated not more than 5 kw, where the circuit conductors of the generator are insulated from the generator frame and all other grounded surfaces, need not be protected with ground-fault circuit interrupters.

- 2.6.3 The employer shall establish and implement an assured equipment grounding conductor program on construction sites covering all cord sets, and receptacles which are not a part of the permanent wiring of the building or structure and equipment connected by cord and plug, which are used by employees. This program shall comply with the following minimum requirements:

- 2.6.3.1 A written description of the program, including the specific procedures adopted by the employer shall be available at the job site for inspection and copying by the concerned authorities and any affected employee.

- 2.6.3.2 The employer shall designate 1 or more qualified persons to implement the program.

- 2.6.3.3 Each cord set, attachment cap, plug and receptacle of cord sets, and any equipment connected by cord and plug including those which are not required to be grounded, except cord sets and receptacles which are fixed and not exposed to damage, shall be visually inspected before each day's use for external defects, such as, deformed or missing pins or insulation damage, and for indication of possible internal damage. Equipment found damaged or defective shall not be used until repaired.

- 2.6.3.4 The following tests shall be performed on all cord sets and receptacles and cord and plug connected equipment required to be grounded, which are not a part of the permanent wiring of the building or structure.

(Note: Double-insulated tools or other similar equipment are not required to be grounded).

All equipment grounding conductors shall be tested for continuity and shall be electrically continuous.

Each receptacle and attachment cap or plug shall be tested for correct attachment of the equipment grounding conductor. The equipment grounding conductor shall be connected to its proper terminal.

- 2.6.3.5 All tests required in item 2.6.3.4 shall be performed:
- Before first use for newly acquired equipment;
 - Before equipment is returned to service following any repairs;
 - Before equipment is used after any incident which can be reasonably suspected to have caused damage (for example, when a cord set is run over); and at intervals not to exceed 3 months, except that cord sets and receptacles which are fixed and not exposed to damage shall be tested at intervals not exceeding 12 months.
- 2.6.3.6 The employer shall not make available or permit the use by employees of any equipment which has not met the requirements of item 2.6.3.
- 2.6.3.7 Receptacles, cord sets and cord and plug connected equipment passing the tests required in item 2.6.3 shall be identified. Identification may be made by means of logs, color coding or other effective means, shall be maintained until replaced by a more current identification, and shall indicate the last test date or the interval for which the tests were performed. These dates or intervals shall be readily available to the concerned authorities and affected employees.
- 2.7 **Grounding and Bonding – See item 9**
- 2.8 **Equipment Installation and Maintenance**
- 2.8.1 Flexible Cable and Cords
- 2.8.1.1 Receptacles for attachment plugs shall be of concealed contact type with a contact for extending ground continuity and shall be so designed and constructed that the plug may be pulled out without leaving any live parts exposed to accidental contact.
- 2.8.1.2 Where different voltages, frequencies, or types of current (AC or DC) are to be supplied by portable cords, receptacles shall be of such design that attachment plugs used on such circuits are not interchangeable.
- 2.8.1.3 Attachment plugs or other connectors supplying equipment at more than 300 volts shall be of the skirted type or otherwise so designed that arcs will be confined.
- 2.8.1.4 Attachment plugs for use in work areas shall be so constructed that they will endure rough usage and be equipped with a suitable cord grip to prevent strain on the terminal screws.
- 2.8.1.5 Flexible cord shall be used only in continuous lengths without splice, except suitable molded or vulcanized splices may be used where properly made. The insulation shall be equal to the cable being spliced and wire connections soldered.
- 2.8.1.6 Trailing cables shall be protected from damage.
- 2.8.1.7 Splices in trailing cable shall be composed of mechanically strong components and insulated to retain the mechanical and dielectric strength or the original cable.
- 2.8.1.8 Cable passing through work areas shall be covered or elevated to protect it from damage which would create a hazard to employees.
- 2.8.1.9 Handlamps shall be of the molded composition or other type approved for the purpose. Brass-shell, paper-lined lampholders shall not be used. Handlamps shall be equipped with a handle and a substantial guard over the bulb and attached to the lampholder or the handle.

- 2.8.1.10 Worn or frayed electric cables shall not be used.
- 2.8.1.11 Extension cords shall be protected against accidental damage as may be caused by traffic, sharp corners, or projections and pinching in doors or elsewhere.
- 2.8.1.12 Extension cords shall not be fastened with staples, hung from nails, or suspended by wire.
- 2.8.2 **Overcurrent Protection**
 - 2.8.2.1 Overcurrent protection shall be provided by fuses or circuit breakers for each feeder and branch circuit, and shall be based on the current-carrying capacity of the conductors supplied and the power load being used.
 - 2.8.2.2 No overcurrent device shall be placed in any permanently grounded conductor, except where the overcurrent device simultaneously opens all conductors of the circuit or for motor protection.
 - 2.8.2.3 When fuses are installed or removed with one or both terminals energized, special tools insulated for the voltage shall be used.
- 2.8.3 **Switches, Circuit Breakers and Disconnecting Means**
 - 2.8.3.1 Each disconnecting means for motors and appliances, and each service feeder or branch circuit at the point where it originates, shall be legibly marked to indicate its purpose unless located and arranged so the purpose is evident.
 - 2.8.3.2 Disconnecting means shall be located or shielded so that employees will not be injured.
 - 2.8.3.3 Boxes for disconnecting means shall be securely and rigidly fastened to the surface upon which they are mounted and fitted with covers.
 - 2.8.3.4 Boxes and disconnecting means installed in damp or wet locations shall be waterproof to the extent that water does not enter or accumulate.
- 2.8.4 **Transformers**
 - 2.8.4.1 Energized transformers and other related electrically energized equipment over 150 volts to ground shall be protected so as to prevent accidental contact with any person. Protection shall be provided by individual integrated housing or by an enclosure, such as an electrical substation fence, which accommodates a group of such equipment. Metallic enclosures shall be grounded.
 - 2.8.4.2 Access to energized equipment covered by item 2.3.4.1 shall be secured by lock or other fasteners requiring the use of tools to open them.
 - 2.8.4.3 Signs indicating danger and prohibiting unauthorized access shall be conspicuously displayed on the housing or other enclosure around the equipment.
 - 2.8.4.4 Transformers mounted on utility poles at a height of more than 4.0 m from the ground are exempt from the requirements of this item 2.8.4.
- 2.8.5 **Welding and Cutting Equipment**

Welding and cutting equipment shall meet the requirements specified in Section 8.0.

3- REQUIREMENTS FOR ELECTRICAL INSTALLATIONS

3.1 Interrupting Rating

Devices intended to break current shall have an interrupting rating sufficient for the voltage employed and for the current that must be interrupted.

3.2 Working Space About Electric Equipment

Sufficient access and working space shall be provided and maintained about all electric equipment to permit ready and safe operation and maintenance of such equipment.

- 3.2.1 Except as elsewhere required or permitted in Section 7.0, the dimension of the working space in the direction of access to live parts which require examination, adjustment, servicing, or maintenance while alive, shall not be less than indicated in Table 1. In addition to the dimensions shown in Table 1, the work space shall not be less than 77 cm wide in front of the electric equipment. Distances shall be measured from the live parts if such are exposed or from the enclosure front or opening if such are enclosed. Concrete, brick, or tile walls shall be considered as grounded.

Table 1
Working Clearances

<u>Voltage to Ground</u>	<u>Minimum Clear Distance (Meters)</u>			
	<u>Condition</u>	<u>1</u>	<u>2</u>	<u>3</u>
0-150		1.0	1.0	1.0
151-600		1.0	1.1	1.2

Where the "Conditions" are as follows:

- (1) Exposed live parts on one side and no live or grounded parts on the other side of the working space, or exposed live parts on both sides effectively guarded by suitable wood or other insulating materials. Insulated wire or insulated busbars operating at not over 300 volts shall not be considered live parts.
- (2) Exposed live parts on one side and grounded parts on the other side.
- (3) Exposed live parts on both sides of the work space with the operator between [not guarded as provided in Condition (1)].

Exception:

Working space shall not be required in back of assemblies, such as dead-front switchboards or motor control centers where there are no renewable or adjustable

parts such as fuses or switches on the back and where all connections are accessible from locations other than the back.

- 3.2.2 Working space required by this item 3.2, shall not be used for storage. When normally enclosed live parts are exposed for inspection or servicing and in a passageway or general open space, the working space shall be suitably guarded.
- 3.2.3 At least one entrance of sufficient area shall be provided to give access to the working space about electric equipment. For switchboards and control panels rated 1200 amperes or more and over 2 m wide, there shall be one entrance not less than 60 cm wide at each end where reasonably practicable.
- 3.2.4 Adequate illumination (50 lux minimum) shall be provided for all working spaces about electric equipment. The light outlets shall be so arranged that persons changing lamps or making repairs on the lighting system will not be endangered by live parts or other equipment.
- 3.2.5 The minimum headroom of working spaces about switchboards, panelboards and motor control centers which require manual operation or where there are live parts exposed at any time shall be 2 m.

As used in this item, a motor control center is an assembly of one or more enclosed sections having a common power bus and principally containing motor control units.

3.3 **Guarding of Live Parts**

- 3.3.1 Except as elsewhere required or permitted by Section 7.0, live parts of electric equipment operating at 50 volts or more shall be guarded against accidental contact by approved cabinets or other forms of approved enclosures or by any of the following means:
 - 3.3.1.1 By location in a room, vault, or similar enclosure that is accessible only to qualified persons.
 - 3.3.1.2 By suitable permanent, substantial partitions or screens so arranged that only qualified persons will have access to the space within reach of the live parts. Any openings in such partitions or screens shall be so sized and located that persons are not likely to come into accidental contact with the live parts or to bring conducting objects into contact with them.
 - 3.3.1.3 By location on a suitable balcony, gallery, or platform so elevated and arranged as to exclude unqualified persons.
 - 3.3.1.4 By elevation of 2.5 m or more above the floor or other working surface.
- 3.3.2 Entrances to rooms and other guarded locations containing exposed live parts shall be marked with conspicuous warning signs forbidding unqualified persons to enter.

3.4 **Arcing Parts**

Parts of electric equipment, which in ordinary operation produce arcs, sparks, flames, or molten metal, shall be enclosed or separated and isolated from all combustible material. For hazardous locations see items 28 through 35 inclusive.

3.5 Marking

On all electrical equipment, markings shall be provided giving voltage, current, wattage, or other ratings. The marking shall be of sufficient durability to withstand the environment involved.

3.6 Identification of Disconnecting Means

Each disconnecting means for motors and utilization equipment, and each service, feeder, or branch circuit at the point where it originates shall be legibly marked to indicate its purpose unless located and arranged so the purpose is evident. The marking shall be of sufficient durability to withstand the environment involved.

3.7 Unused Openings

Unused openings in boxes, enclosures or fittings shall be effectively closed to afford protection substantially equivalent to that of the wall of the box, enclosure, or fitting.

3.8 Control and Protective Devices

All switches, circuit breakers, fuses and other control and protective devices shall be so located or arranged that they may be safely operated, removed or repaired.

4- USE AND IDENTIFICATION OF GROUNDED CONDUCTORS**4.1 General**

All premises wiring systems utilizing a neutral shall have that neutral grounded as required by good engineering practice.

4.2 Connection to Grounded System

Premises wiring shall be electrically connected to a supply system unless the latter contains, for any grounded conductor of the interior system, a corresponding conductor which is grounded.

For the purpose of this item, "electrically connected" shall mean connection capable of carrying current as distinguished from connection through electromagnetic induction.

4.3 Means of Identifying Grounded Conductors

An insulated grounded conductor shall be distinctively marked by combination of green and yellow colour coding so as to be readily distinguishable from other conductors.

Exception:

The grounded conductor of a mineral-insulated metal-sheathed cable shall be identified at the time of installation by distinctive marking at its terminations.

4.4 Means of Identification of Terminals

The identification of terminals to which a grounded conductor is to be connected shall be by such means that they are readily distinguishable from other terminals.

4.5 Means of Identifying Grounding Conductor

A grounding conductor shall be distinctively marked by a continuous and yellow

stripe colour coding so as to be readily distinguishable from other conductors unless it is bare.

4.6 **Identification of Terminals**

- 4.6.1 All devices provided with terminals for the attachment of conductors and intended for connection to more than one side of the circuit shall have terminals properly marked for identification:

Exception No. 1:

Where the electrical connection of a terminal intended to be connected to the grounded conductor is clearly evident.

Exception No. 2:

Single-pole devices to which only one side of the line is connected.

Exception No. 3:

The terminals of lighting and appliance branch circuit panelboards.

Exception No. 4:

Devices having a normal current rating of over 30 amperes other than polarized attachment plugs and polarized receptacles as required in item 4.6.2.

- 4.6.2 Receptacles, polarized attachment plugs and cord connectors for plugs and polarized plugs shall have the terminal intended for connection to the grounded conductor distinctively identified. If the terminal for the grounded conductor is not visible, the conductor entrance hole for the connection shall be distinctively marked.

The terminal for the connection of the equipment grounding conductor shall be identified by a distinctively marked, not readily removable terminal screw, not readily removable terminal nut, or a pressure wire connector. If the terminal for the grounding conductor is not visible, the conductor entrance hole shall be distinctively marked.

Exception:

Two-wire attachment plugs shall not be required to have their terminals marked for identification.

- 4.6.3 For devices with screw-shells the terminal for the grounded conductor shall be the one connected to the screw-shell.
- 4.6.4 For screw-shell devices with attached leads, the conductor attached to the screw-shell shall be distinctively marked. The outer finish of the other conductor shall be of a solid color that will not be confused with the finish used to identify the grounded conductor.

4.7 **Polarity of Connections**

No grounded conductor shall be attached to any terminal or lead so as to reverse designated polarity.

5- BRANCH CIRCUITS**5.1 Scope**

The provisions of this item 5, apply to branch circuits supplying lighting or utilization equipment loads or combinations of both. Where motors or motor-operated utilization equipment is connected to any branch circuit that also supplies lighting or other utilization equipment loads, the provisions of both this item 5 and item 22 shall apply. Item 22 applies where a branch circuit supplies motor loads only.

5.2 Color Code for Branch Circuits

5.2.1 The grounded and grounding conductors shall be identified according to the provisions of items 4.3 and 4.5 respectively. Where conductors of different systems are installed in the same raceway, box, auxiliary gutter, or other types of enclosures, each system neutral shall be identified so as to be readily distinguishable from the other system neutrals as well as from the other conductors in the enclosure.

5.2.2 Upgrounded conductors of different voltages shall be of different color or identified by other means.

5.3 Maximum Voltage

5.3.1 Branch circuits supplying lampholders, fixtures, or standard receptacles rated 15 amperes or less shall not exceed 150 volts to ground.

Exception No. 1:

The voltage shall not exceed 300 volts to ground on branch circuits where all the following conditions are met:

- (1) The conditions of maintenance and supervision assure that only competent individuals will service the lighting fixtures.
- (2) The branch circuits supply only lighting fixtures that are equipped with mogul-base screw-shell lampholders or with lampholders of other types approved for the purpose.
- (3) The fixtures are mounted not less than 2.5 m above the floor.
- (4) Integral lighting switch, if used, shall not be readily accessible.

Exception No. 2:

For lampholders of infrared industrial heating appliances as provided in item 19.2.4.3.

5.3.2 The voltage shall not exceed 500 volts between conductors on branch circuits supplying only the ballasts for electric-discharge lamps mounted in permanently installed fixtures where the fixtures are mounted as indicated in items 5.3.2.1 through 5.3.2.2 below.

5.3.2.1 Not less than a height of 7 m on poles or similar structures for the illumination of outdoor areas, such as highways, roads, bridges, or parking lots.

5.3.2.2 Not less than a height of 5.5 m on other structures, such as tunnels.

5.3.3 The voltage shall not exceed 150 volts between conductors on branch circuits

supplying one or more medium-base, screw-shell lampholders.

See Exception No. 1 to item 5.3.1 for 300 volt limitation for mogul-base screw-shell lampholders under specific conditions.

5.4 **Receptacles and Cord Connectors**

- 5.4.1 Receptacles installed on 15 and 20 ampere branch circuits shall be of the grounding type. Grounding type receptacles shall be installed only on circuits of the voltage class and current for which they are rated.

Exception No. 1:

Receptacles rated 15 amperes shall be permitted to be installed on 20 ampere circuits supplying two or more receptacles or outlets.

Exception No. 2:

Grounding type receptacles of the type that reject nongrounding-type attachment plugs or which are of the locking type shall be permitted for specific purposes or in special locations.

- 5.4.2 Receptacles and cord connectors having grounding contacts shall have those contacts effectively grounded.

- 5.4.3 The grounding contacts of receptacles and cord connectors shall be grounded by connection to the equipment grounding conductor of the circuit supplying the receptacle or cord connector.

The branch circuit or branch-circuit raceway shall include or provide a grounding conductor to which the grounding contacts of the receptacle or cord connector shall be connected. Item 9.7.1.2 describes acceptable grounding means.

Exception:

Only for extensions of existing branch circuits that do not have an equipment grounding conductor, the grounding contact of a grounding-type receptacle shall be permitted to be grounded to a grounded metal cold water pipe near the equipment.

- 5.4.4 Grounding-type receptacles shall be used as replacements for existing nongrounding types and shall be connected to a grounding conductor installed in accordance with item 5.4.3.

Exception:

If it is impractical to reach a source of ground, a nongrounding-type receptacle may be used.

- 5.4.5 The installation of grounding-type receptacles shall not be used as a requirement that all portable equipment be of the grounded type. See item 9.3.4 for type of portable equipment to be grounded.

- 5.4.6 Receptacles connected to circuits having different voltages, frequencies, or types of current (AC or DC) on the same premises shall be of such design that the attachment plugs used on these circuits are not interchangeable.

5.5 **Ground Fault Personnel Protection (Construction Sites)**

Refer to item 2.6.

6- OUTSIDE BRANCH CIRCUITS AND FEEDERS**6.1 Scope**

This item 6, covers electric equipment and wiring for the supply of utilization equipment located on or attached to the outside of buildings, or run between buildings, other structures or poles on other premises serviced.

6.2 Lighting Equipment on Poles or Other Structures**6.2.1** Branch circuits supplying lampholders or lighting fixtures mounted on the outside of buildings or on poles or structures for area illumination shall not exceed 150 volts to ground.**Exception:**

The voltage shall not exceed 300 volts to ground on branch circuits supplying lighting fixtures for illumination of outdoor areas where all of the following conditions are met:

- (1) The fixtures are mounted on the outside of buildings or out-of-doors on poles or other structures.
- (2) The fixtures are not less than 2.5 m above ground or other surface inaccessible to individuals other than those charged with fixture maintenance and supervision.
- (3) The fixtures are not less than 1 m from windows, platforms, fire escapes, and the like.

6.2.2 The voltage between conductors on branch circuits supplying only the ballast for permanently installed electric-discharge fixtures for area illumination shall be in accordance with item 5.3.2.**6.3 Open-Conductor Supports**

Open conductors shall be supported on glass or porcelain knobs, racks, brackets, or strain insulators.

6.4 Festoon Supports

In spans exceeding 12 m, the conductors shall be supported by a messenger wire, and the messenger wire shall be supported by strain insulators. Conductors or messenger wires shall not be attached to any fire escape, downspout, or plumbing equipment.

Definition: Festoon lighting is a string of outdoor lights suspended between two points more than 5 m apart.

6.5 Clearance from Ground

Open conductors of not over 600 volts shall conform to the following:

Above areas (other than thoroughfares)

where it is possible to drive vehicles 5 m

Above areas accessible to pedestrians only 4 m

6.6 Clearances from Buildings for Conductors of Not Over 600 Volts**6.6.1** Open conductors shall have a clearance of not less than 2.5 m from the highest

point of roofs over which they pass.

Exception No. 1:

Where the voltage between conductors does not exceed 300 volts and the roof has a slope of not less than 1:3, a reduction in clearance to 1 m shall be permitted.

Exception No. 2:

Where the voltage between conductors does not exceed 300 volts, a reduction in clearance over the roof to 50 cm shall be permitted if: (1) they do not pass over more than 1.2 m of the overhang portion of the roof, and (2) they are terminated at a through-the-roof raceway or approved support.

6.6.2 Open conductors not attached to a building shall have a minimum horizontal clearance of 1 m.

6.6.3 Final spans of feeders or branch circuits to a building they supply or from which they are fed shall be permitted to be attached to the building, but they shall be kept 1 m from windows, doors, fire escapes, or similar locations.

Conductors run above the top level of a window shall be considered out of reach from that window.

6.7 Open Conductor Spacing

6.7.1 Open conductors shall be separated from open conductors of other circuits or systems by not less than 10 cm.

6.7.2 Conductors on poles shall have a separation of not less than 30 cm where not placed on racks or brackets. Conductors supported on poles shall provide a horizontal climbing space not less than the following:

Power conductors, below communication conductors 80 cm

Power conductors alone or above communication
conductors:

300 volts or less 60 cm

Over 300 volts 80 cm

Communication conductors below power conductors, same as power conductors.

Communication conductors alone, no requirement.

6.8 Location of Outdoor Lamps

Locations of lamps for outdoor lighting shall be below all live conductors, transformers, or other electric equipment.

Exception No. 1:

Where clearances or other safeguards are provided for relamping operations.

Exception No. 2:

Where equipment is controlled by a disconnecting means that can be locked in the open position.

7- SERVICES**7.1 Scope**

This item 7, covers service conductors and equipment for control and protection of services; the types of services and service equipment; and the installation requirements.

7.2 Clearances

Service-drop conductors shall not be readily accessible and shall comply with items 7.2.1 thru 7.2.3.

7.2.1 Conductors shall have a clearance of not less than 2.5 m from the highest point of roofs over which they pass.**Exception No. 1:**

Where the voltage between conductors does not exceed 300 volts and the roof has a slope of not less than 1:3, a reduction in clearance to 1 m shall be permitted.

Exception No. 2:

Where the voltage between conductors does not exceed 300 volts, a reduction in clearance over the roof to not less than 50 cm shall be permitted if (1) they do not pass over more than 1.2 m of the overhang portion of the roof, and (2) they are terminated at a through-the-roof raceway or approved support.

7.2.2 Service-drop conductors shall have the following minimum clearance from ground:

Above areas (other than thoroughfares) where it

is possible to drive vehicles 5 m

Above areas accessible to pedestrians only 4 m

7.2.3 Conductors shall have a clearance of not less than 1 m from windows, doors, porches, fire escapes, or similar locations.

Conductors run above the top level of a window shall be considered out of reach from that window.

7.3 Point of Attachment

The point of attachment of conductors to a building or other structure shall provide the minimum clearances as specified in item 7.2. In no case shall this point of attachment be less than 3 m above finished grade.

7.4 Service Equipment – Enclosed or Guarded

Live parts of service equipment shall be enclosed as specified in item 7.4.1, or guarded as specified in item 7.4.2.

7.4.1 Live parts shall be enclosed so that they will not be exposed to accidental contact or guarded as in item 7.4.2.**7.4.2** Live parts that are not enclosed shall be installed on a switchboard, panelboard, or control board and guarded in accordance with items 3.3 and 3.4. Such an enclosure shall be provided with means for locking or sealing doors giving access to live parts.

7.5 Manually or Power Operable Service Disconnecting Means

The disconnecting means for ungrounded conductors shall consist of either (1) a manually operable switch or circuit breaker equipped with a handle or other suitable operating means, or (2) a power-operated switch or circuit breaker provided the switch or circuit breaker can be opened by hand in the event of a power supply failure.

7.6 Indicating

The service disconnecting means shall plainly indicate whether it is in the open or closed position.

7.7 Externally Operable

An enclosed service disconnecting means shall be externally operable without exposing the operator to contact with live parts.

Exception:

A power-operated switch or circuit breaker shall not be required to be externally operable by hand to the closed position.

8- OVERCURRENT PROTECTION**8.1 General**

Overcurrent protection shall be provided for the protection of conductors and equipment in accordance with good engineering practice.

8.2 Enclosures

Overcurrent devices shall be enclosed in cabinets or cut out boxes.

Exception No. 1:

Where a part of an assembly provides equivalent protection.

Exception No. 2:

The operating handle of a circuit breaker shall be permitted to be accessible without opening a door or cover.

8.3 Disconnecting and Guarding**8.3.1 Disconnecting means shall be provided on the supply side of all fuses or thermal cutouts in circuits over 150 volts to ground and cartridge fuses in circuits of any voltage, so that each individual circuit containing fuses or thermal cutouts can be independently disconnected from the source of electric energy.****Exception No. 1:**

Where fuses are permitted on the supply side of the service disconnecting means.

Exception No. 2:

A single disconnecting means shall be permitted on the supply side of more than one set of fuses as provided by item 22.4.6 for group operation of motors and for fixed space heating equipment.

8.3.2 Arcing or suddenly moving parts shall comply with items 8.3.2.1 and 8.3.2.2

below.

- 8.3.2.1 Fuses and circuit breaker shall be so located or shielded that persons will not be burned or otherwise injured by their operation.
- 8.3.2.2 Handles or levers of circuit breakers, and similar parts which may move suddenly in such a way that persons in the vicinity are liable to be injured by being struck by them, shall be guarded or isolated.

8.4 **Plug Fuses, Fuseholds, and Adapters**

- 8.4.1 Plug fuses and fuseholders shall not be used in circuits exceeding 125 volts between conductors.
- 8.4.2 Plug fuses, fuseholders, and adapters shall have no exposed live parts after fuses or fuses and adapters have been installed.
- 8.4.3 Renewable link fuses shall not be used.

8.5 **Cartridge Fuses and Fuseholders**

Cartridge fuses and fuseholders of the 300 volt type shall not be used in circuits of over 300 volts between conductors.

Exception:

In circuits supplied by a system having a grounded neutral and having no conductor at over 300 volts to ground.

8.6 **Circuit Breakers**

- 8.6.1 Circuit breakers shall be trip-free and capable of being closed and opened by manual operation. Their normal method of operation by other than manual means such as electrical or pneumatic shall be permitted if means for manual operation is also provided.
- 8.6.2 Circuit breakers shall clearly indicate whether they are in the open (OFF) or closed (ON) position.

Where circuit breaker handles on switchboards are operated vertically rather than rotationally or horizontally, the up position of the handle shall be the ON position.

8.6.3 **Marking**

- 8.6.3.1 Circuit breakers shall be marked with their rating in a manner that will be durable and visible after installation. Such marking shall be visible after removal of a trim or cover.
- 8.6.3.2 Circuit breakers rated at 100 amperes or less shall have the ampere rating molded, stamped, etched, or similarly marked into their handles or excutcheon areas.
- 8.6.3.3 Every circuit breaker having an interrupting rating other than 5,000 amperes shall have its interrupting rating shown on the circuit breaker.

9- **GROUNDING**

9.1 **General**

9.1.1 Scope

This item 9, covers general requirements for grounding and bonding of electrical installations, and specific requirements as listed below.

Systems, circuits, and equipment required, permitted, or not permitted to be grounded.

Location of grounding connections.

Types and sizes of grounding and bonding conductors and electrodes.

Methods of grounding and bonding.

Conditions under which guards, isolation, or insulation may be substituted for grounding.

Conductive materials enclosing electric conductors or equipment, or forming part of such equipment, are grounded for the purpose of preventing a voltage above ground on these materials.

9.1.2 Systems and Circuit Grounding

Systems and circuits shall be grounded in accordance with good engineering practice.

9.2 Enclosure Grounding

9.2.1 Metal enclosures for service conductors and equipment shall be grounded.

9.2.2 Metal enclosures for other than service conductors shall be grounded.

Exception No. 1:

Metal enclosures are not required to be grounded for conductors added to existing installations of open-wire, knob-and-tube wiring, and nonmetallic-sheathed cable, if in runs of less than 8 m, if free from probable contact with ground, grounded metal, metal lath, or other conductive material; and if guarded against contact by persons.

Exception No. 2:

Metal enclosures used to protect cable assemblies from physical damage are not required to be grounded.

9.3 Equipment Grounding**9.3.1 Fixed Equipment, General**

Exposed noncurrent-carrying metal parts of fixed equipment likely to become energized under abnormal conditions shall be grounded under any of the conditions specified in items 9.3.1.1 through 9.3.1.6 below.

9.3.1.1 Where within 2.5 m vertically or 1.5 m horizontally of ground or grounded metal objects and subject to contact by persons.

9.3.1.2 Where located in a wet or damp location and not isolated.

9.3.1.3 Where in electrical contact with metal.

9.3.1.4 Where in a hazardous location as covered by items 28 through 36.

9.3.1.5 Where supplied by a metal-clad, metal-sheathed, or metal-raceway wiring method,

except as permitted by item 9.2.2 for short sections of raceway.

- 9.3.1.6 Where equipment operates with any terminal at over 150 volts to ground.

Exception No. 1:

Enclosures for switches or circuit breakers used for other than service equipment and accessible to qualified persons only.

Exception No. 2:

Metal frames of electrically heated devices, exempted by special permission, in which case the frames shall be permanently and effectively insulated from ground.

Exception No. 3:

Distribution apparatus, such as transformer and capacitor cases, mounted on wooden poles, at a height exceeding 2.5 m above ground or grade level.

9.3.2 **Fixed Equipment – Specific**

Exposed, noncurrent-carrying metal parts of the kinds of equipment described in items 9.3.2.1 through 9.3.2.6 below, regardless of voltage, shall be grounded:

- 9.3.2.1 Switchboard frames and structures supporting switching equipment.

Exception:

Frames of DC, single-polarity switchboards where effectively insulated.

- 9.3.2.2 Motor frames.

- 9.3.2.3 Enclosures for motor controllers.

Exception:

Lined covers of snap switches.

- 9.3.2.4 Electric equipment for elevators and cranes.

- 9.3.2.5 Electric signs and associated equipment.

Exception:

Where insulated from ground and from other conductive objects and accessible only to authorized persons.

- 9.3.2.6 Lighting fixtures as provided in item 18.4.

9.3.3 **Nonelectrical Equipment**

The metal parts of nonelectrical equipment described in items 9.3.3.1 thru 9.3.3.3 below shall be grounded.

- 9.3.3.1 Frames and tracks of electrically operated cranes.

- 9.3.3.2 Frames of nonelectrically driven elevator cars to which electric conductors are attached.

- 9.3.3.3 Metal partitions, grill work, and similar metal enclosures around equipment of over 600 volts between conductors except substations or vaults under the sole control of the supply company.

Where extensive metal in or on buildings may become energized and is subject to

personal contact, adequate bonding and grounding is required.

9.3.4 **Equipment Connected by Cord and Plug**

Under any of the conditions described in items 9.3.4.1 through 9.3.4.3 below, exposed noncurrent-carrying metal parts of cord and plug connected equipment likely to become energized, shall be grounded.

9.3.4.1 In hazardous locations.

9.3.4.2 Where operated at over 150 volts to ground.

Exception No. 1:

Motors, where guarded.

Exception No. 2:

Metal frames of electrically heated appliances.

9.3.4.3 (1) Hand-held, motor-operated tools; (2) portable handlamps; (3) sump pumps; (4) cord and plug connected equipment used in damp or wet locations or by persons standing on the ground or on metal floors or working inside of metal tanks or boilers; and (5) tools likely to be used in wet and conductive locations.

Exception No. 1:

Tools likely to be used in wet and conductive locations shall not be required to be grounded where supplied through an isolating transformer with an ungrounded secondary of not over 50 volts.

Exception No. 2:

Portable tools and equipment protected by an approved system of double insulation, or its equivalent, shall not be required to be grounded. Where such a system is employed, the equipment shall be distinctively marked.

9.3.5 Metal raceways, enclosures, frames, and other noncurrent-carrying metal parts of electric equipment shall be kept at least 2 m away from lightning rod conductors or they shall be bonded to the lightning rod conductors.

9.4 **Methods of Grounding**

9.4.1 **Equipment Grounding Connections**

The grounding connection for metal noncurrent-carrying equipment shall be made on the supply side of the service disconnecting means or, for a separately derived system, at the source of the separately derived system and ahead of any system disconnecting means or overcurrent device.

9.4.1.1 **For Grounded System**

The connection shall be made by bonding the equipment grounding conductor to the grounded circuit conductor and the grounding electrode conductor.

9.4.1.2 **For Ungrounded System**

The connection shall be made by bonding the equipment grounding conductor to the grounding electrode conductor.

Exception:

For branch-circuit extensions only in existing installations which do not have a grounding conductor in the branch circuit, the grounding conductor of a grounding-type receptacle outlet may be grounded to a grounded cold water pipe near the equipment.

9.4.2 Effective Grounding Path

The path to ground from circuits, equipment, and conductor enclosures shall: (1) be permanent and continuous, and (2) have ample carrying capacity to conduct safely any currents liable to be imposed on it, and (3) have impedance sufficiently low to limit the potential above ground and to facilitate the operation of the circuit protective devices in the circuit.

9.4.3 Grounding Path to Grounding Electrode**9.4.3.1 Grounding Electrode Conductor**

A grounding electrode conductor shall be used to connect the equipment grounding conductors, the service equipment enclosures and where the system is grounded, the grounded conductor to the grounding electrode.

9.4.3.2 For a grounded system, an unspliced main bonding jumper shall be used to connect the equipment grounding conductor and the service equipment enclosure to the grounded conductor of the system within the service equipment or within the service conductor enclosure. A main bonding jumper shall be a wire, bus, screw, or similar suitable conductor.

9.4.4 Common Grounding Electrode

Where an AC system is connected to a grounding electrode in or at a building, the same electrode shall be used to ground conductor enclosures and equipment in or on that building. Two or more electrodes that are effectively bonded together shall be considered as a single electrode in this sense.

9.4.5 Fixed Equipment Grounding

Metal noncurrent-carrying equipment where required to be grounded shall be grounded by one of the methods indicated in items 9.4.5.1, 9.4.5.2 or 9.4.5.3 below.

9.4.5.1 By any of the equipment grounding conductors permitted by item 9.7.1.2.

9.4.5.2 By an equipment grounding conductor contained within the same raceway, cable, or cord or otherwise run with the circuit conductors. Bare, covered or insulated equipment grounding conductors shall be permitted. Individually covered or insulated grounding conductors shall be distinctively marked to be readily distinguishable from other conductors.

Exception No. 1:

Where the conditions of maintenance and supervision assure that only qualified persons will service the installation, an insulated conductor in a multiconductor cable shall, at the time of installation, be permitted to be permanently identified as a grounding conductor at each end and at every point where the conductor is accessible by one of the following means:

- (1) Stripping the insulation from the entire exposed length.
- (2) Colouring code the insulation green/yellow.
- (3) Marking the exposed insulation with green tape or coloured adhesive labels.

Exception No. 2:

For direct-current circuits only, the equipment grounding conductor shall be permitted to be run separately from the circuit conductors.

- 9.4.5.3 By special permission from concerned authorities, other means for grounding fixed equipment may be used.

9.4.6 **Equipment Considered Effectively Grounded**

The following noncurrent-carrying equipment, under the conditions specified in items 9.4.6.1 and 9.4.6.2 below, shall be considered effectively grounded:

- 9.4.6.1 Electric equipment secured to and in electrical contact with a metal rack or structure provided for its support and grounded by one of the means indicated in item 9.4.5. The structural metal frame of a building shall not be used as the required equipment grounding conductor for AC equipment.
- 9.4.6.2 Metal car frames supported by metal hoisting cables attached to or running over metal sheaves or drums of grounded elevator machines.

9.4.7 **Cord and Plug Connected Equipment**

Noncurrent-carrying metal parts of cord and plug connected equipment where required to be grounded, shall be grounded by one of the methods indicated in items 9.4.7.1, 9.4.7.2 or 9.4.7.3 below.

- 9.4.7.1 By means of the metal enclosure of the conductors supplying such equipment if grounding type attachment plug with one fixed grounding contact is used for grounding the metal enclosure, and if the metal enclosure of the conductors is secured to the attachment plug and to equipment by connectors approved for the purpose.

Exception:

A self-restoring grounding contact shall be permitted on grounding-type attachment plugs used on the power supply cord of portable hand-held, hand-guided, or hand-supported tools or appliances.

- 9.4.7.2 By means of a grounding conductor run with the power supply conductors in a cable assembly or flexible cord properly terminated in grounding-type attachment plug with one fixed grounding contact. An uninsulated grounding conductor shall be permitted but, if individually covered, the covering shall be green/yellow stripped so that the grounding conductor is readily distinguishable from other conductors.

Exception:

A self-restoring grounding contact shall be permitted on grounding-type attachment plugs used on the power supply cord of portable hand-held, hand-guided, or hand-supported tools or appliances.

- 9.4.7.3 By means of a separate flexible wire or strap, insulated or bare, protected as well as practicable against physical damage, where part of equipment, or by special

permission.

9.4.8 **Use of Grounded Circuit Conductor for Grounding Equipment**

9.4.8.1 A grounded circuit conductor shall be permitted to ground noncurrent-carrying metal parts of equipment on the supply side of the service disconnecting means, such as meter enclosures, service raceways, etc., and on the supply side of the main disconnecting means of separate buildings and of separately derived systems.

9.4.8.2 A grounded circuit conductor shall not be used for grounding noncurrent-carrying metal parts of equipment on the load side of the service disconnecting means or on the load side of a separately derived system disconnecting means or the overcurrent devices for a separately derived system not having a main disconnecting means.

9.4.9 **Multiple Circuit Connections**

Where equipment is required to be grounded, and is supplied by separate connection to more than one circuit or grounded premises wiring system, a means for grounding shall be provided for each such connection.

9.5 **Bonding**

9.5.1 **General**

Bonding shall be provided where necessary to assure electrical continuity and the capacity to conduct safely any fault current likely to be imposed.

9.5.2 **Bonding Service Equipment**

The noncurrent-carrying metal parts of equipment indicated in items 9.5.2.1, 9.5.2.2, and 9.5.2.3 below shall be effectively bonded together, including:

9.5.2.1 Service raceways, cable trays, or service cable armour or sheath;

9.5.2.2 All service equipment enclosures containing service-entrance conductors, including meter fittings, boxes, or the like, interposed in the service raceway or armour;

9.5.2.3 Any conduit or armour enclosing a grounding electrode conductor.

9.5.3 **Method of Bonding Service Equipment**

Electrical continuity at service equipment shall be assured by one of the methods specified in items 9.5.3.1 through 9.5.3.5 below.

9.5.3.1 Bonding equipment to the grounded service conductor in a manner provided in item 9.8.3.

9.5.3.2 Threaded couplings and threaded bosses on enclosures with joints shall be wrench-tight where rigid metal conduit and intermediate metal conduit are involved.

9.5.3.3 Threadless couplings securely fastened for rigid metal conduit, intermediate metal conduit and electrical metallic tubing.

9.5.3.4 Bonding jumpers meeting the other requirements of this item 9. Bonding jumpers shall be used around concentric or eccentric knockouts that are punched or otherwise formed so as not to impair the electrical connection to ground.

9.5.3.5 Other devices, such as bonding-type locknuts and bushings, approved for the

purpose.

9.5.4 **Metal Armour or Tape of Service Cable**

The metal covering of service cable having an uninsulated grounded service conductor in continuous electrical contact with its metallic armour or tape shall be considered to be grounded.

9.5.5 **Connecting Receptacle Grounding Terminal to Box**

An equipment bonding jumper shall be used to connect the grounding terminal of a grounding-type receptacle to a grounded box.

Exception No. 1:

Where the box is surface-mounted, direct metal-to-metal contact between the device yoke and the box shall be permitted to ground the receptacle to the box.

Exception No. 2:

Contact devices or yokes designed for the purpose shall be permitted in conjunction with the supporting screws to establish the grounding circuit between the device yoke and flush-type boxes.

Exception No. 3:

Floor boxes designed for and providing satisfactory ground continuity between the box and the device.

Exception No. 4:

Where required for the reduction of electrical noise (electromagnetic interference) on the grounding circuit, a receptacle in which the grounding terminal is purposely insulated from the receptacle mounting means shall be permitted. The receptacle grounding terminal shall be grounded by an insulated equipment grounding conductor run with the circuit conductors. This grounding conductor shall be permitted to pass through one or more panelboards without connection to the panelboard grounding terminal so as to terminate directly at the applicable derived system or service grounding terminal.

9.5.6 **Bonding Other Enclosures**

Metal raceways, cable armour, cable sheath, enclosures, frames, fittings, and other metal noncurrent-carrying parts that are to serve as grounding conductors shall be effectively bonded where necessary to assure electrical continuity and the capacity to conduct safely any fault current likely to be imposed on them. Any nonconductive paint, enamel, or similar coating shall be removed at threads, contact points, and contact surfaces or be connected by means of fittings so designed as to make such removal unnecessary.

9.5.7 **Bonding for Over 250 Volts**

For circuits of over 250 volts to ground, the electrical continuity of metal raceways and cables with metal sheaths that contain any conductor other than service conductors shall be assured by 1 or more of the methods specified for services in items 9.5.3.2 through 9.5.3.5 or by items 9.5.7.1 or 9.5.7.2 below.

9.5.7.1 Threadless fittings made tight, with conduit or metal-clad cable.

9.5.7.2 Two locknuts, 1 inside and 1 outside of boxes and cabinets.

9.5.8 Bonding Loosely Jointed Metal Raceways

Expansion joints and telescoping sections of raceways shall be made electrically continuous by equipment bonding jumpers or other means approved for the purpose.

9.5.9 Bonding in Hazardous Locations

Regardless of the voltage of the electrical system, the electrical continuity of metal noncurrent-carrying equipment in any hazardous location as defined in item 28 shall be assured by any of the methods specified for services that are approved for the wiring method used.

9.5.10 Main and Equipment Bonding Jumpers

9.5.10.1 Material

Main and equipment bonding jumpers shall be of copper or other corrosion-resistant material.

9.5.10.2 Attachment

Main and equipment bonding jumpers shall be attached in the manner specified by the applicable provisions of item 9.8.3 for circuits and equipment and by item 9.8.5 for grounding electrodes.

9.5.10.3 Size - Equipment Bonding Jumper on Supply Side of Service and Main Bonding Jumper

The bonding jumper shall not be smaller than the sizes given in Table 2 for grounding electrode conductors. Where the service-entrance phase conductors are larger than those shown in Table 2, the bonding jumper shall have an area not less than 12.5 percent of the area of the largest phase conductor except that where the phase conductors and the bonding jumper are of different materials (copper or aluminum), the minimum size of the bonding jumper shall be based on the assumed use of phase conductors of the same materials as the bonding jumper and with an ampacity equivalent to that of the installed phase conductors. Where the service-entrance conductors are paralleled in 2 or more raceways, the size of the bonding jumper for each raceway shall be based on the size of service conductors in each raceway.

9.5.10.4 Size - Equipment Bonding Jumper on Load Side of Service

The equipment bonding jumper on the load side of the service overcurrent devices shall not be smaller than the sizes listed by Table 3 for equipment grounding conductors.

9.5.10.5 Installation - Equipment Bonding Jumper

The equipment bonding jumper shall be permitted to be installed inside or outside of a raceway or enclosure. Where installed on the outside, the length of the equipment bonding jumper shall not exceed 1.8 m and shall be routed with the raceway or enclosure.

9.5.11 Bonding of Piping Systems

9.5.11.1 Metal Water Piping

The interior metal water piping system shall always be bonded to the service equipment enclosure, the grounded conductor at the service, the grounding electrode conductor where of sufficient size, or to the 1 or more grounding electrodes used. The bonding jumper shall be sized in accordance with Table 2.

9.5.11.2 Other Metal Piping

Interior metal piping which may become energized shall be bonded to the service equipment enclosure, the grounded conductor at the service, the grounding electrode conductor where of sufficient size, or to the 1 or more grounding electrodes used. The bonding jumper shall be sized in accordance with Table 3 using the rating of the circuit which may energize the piping.

The equipment grounding conductor for the circuit which may energize the piping shall be permitted to serve as the bonding means.

9.6 Grounding Electrode System

9.6.1 Grounding Electrode System

If available on the premises at each building or structure served, each item in items 9.6.1.1 through 9.6.1.4 below shall be bonded together to form the grounding electrode system. The bonding jumper shall be sized in accordance with item 9.5.10.3 and shall be connected in the manner specified in item 9.8.5.

9.6.1.1 A metal underground water pipe in direct contact with the earth for 3 m or more (including any metal well casing effectively bonded to the pipe) and electrically continuous (or made electrically continuous by bonding around insulating joints or sections or insulating pipe) to the points of connection of the grounding electrode conductor and the bonding conductors. Continuity of the grounding path or the bonding connection to interior piping shall not rely on water meters. A metal underground water pipe shall be supplemented by an additional electrode of a type specified in item 9.6.1 or in item 9.6.2.

9.6.1.2 The metal frame of the building, where effectively grounded.

9.6.1.3 An electrode encased by at least 5 cm of concrete, located within and near the bottom of a concrete foundation or footing that is in direct contact with the earth, consisting of at least 6 m of 1 or more steel reinforcing bars or rods of not less than 15 mm diameter, or consisting of at least 6 m of bare solid copper conductor not smaller than 7 mm in diameter.

9.6.1.4 A ground ring encircling the building or structure, in direct contact with the earth at a depth below earth surface not less than 75 cm, consisting of at least 6 m of bare copper conductor not smaller than 7 mm in diameter.

9.6.2 Made and Other Electrodes

Where none of the electrodes specified in item 9.6.1 are available, 1 or more of the electrodes specified in 9.6.2.1 through 9.6.2.4 below shall be used. Where practicable, made electrodes shall be embedded below permanent moisture level. Made electrodes shall be free from nonconductive coatings, such as paint or enamel. Where more than 1 electrode system is used (including those used for lightning rods), each electrode of 1 system shall not be less than 2 m from any other electrode of another system.

Two or more electrodes that are effectively bonded together are to be treated as a

single electrode system in this sense.

9.6.2.1 **Underground Gas Piping System**

An electrically continuous metal underground gas piping system that is uninterrupted with insulating sections or joints and without an outer nonconductive coating, and then only if acceptable to and expressly permitted by both the serving gas supplier and the authority having jurisdiction.

9.6.2.2 **Other Metal Underground Systems**

Other local metal underground systems or structures, such as piping systems and underground tanks.

9.6.2.3 **Rod and Pipe Electrodes**

Rod and pipe electrodes shall not be less than 2.5 m in length and shall consist of the materials, and shall be installed in the manner indicated in items 9.6.2.3.1, 9.6.2.3.2 and 9.6.2.3.3, below.

9.6.2.3.1 Electrodes of pipe or conduit shall not be smaller than 23 mm trade size and, where of iron or steel, shall have the outer surface galvanized or otherwise metal-coated for corrosion protection.

9.6.2.3.2 Electrodes or rods of steel or iron shall be at least 15 mm in diameter. Nonferrous rods or their equivalent shall be not less than 12 mm in diameter.

9.6.2.3.3 Where rock bottom is not encountered, the electrode shall be driven to a depth of 2.5 m. Where rock bottom is encountered at a depth of less than 1.2 m, electrodes not less than 2.5 m long shall be buried in a trench.

9.6.2.4 **Plate Electrodes**

Each plate electrode shall expose not less than 1 sq m of surface to exterior soil. Electrodes of iron or steel plates shall be at least 6 mm in thickness. Electrodes of nonferrous metal shall be at least 1.5 mm in thickness.

9.6.3 **Resistance of Made Electrodes**

A single electrode consisting of a rod, pipe, or plate which does not have a resistance to ground of 25 ohms or less shall be augmented by 1 additional electrode of any of the types specified in items 9.6.1 or 9.6.2.

9.6.4 **Use of Lightning Rods**

Lightning rod conductors and driven pipes, rods, or other made electrodes used for grounding lightning rods shall not be used in lieu of the made grounding electrodes required by items 9.6.1 or 9.6.2 for grounding wiring systems and equipment. This provision shall not prohibit the bonding together of grounding electrodes of different systems.

Bonding together of all separate electrodes will limit potential differences between them and between their associated wiring systems.

9.7 **Grounding Conductors**

9.7.1 **Material**

The material for grounding conductors shall be as specified in items 9.7.1.1 and 9.7.1.2 below.

- 9.7.1.1 The grounding electrode conductor shall be of copper, aluminum, or copper-clad aluminum. The material selected shall be resistant to any corrosive condition existing at the installation or shall be suitably protected against corrosion. The conductor shall be solid or stranded, insulated, covered, or bare and shall be installed in 1 continuous length without a splice or joint.

Exception No. 1:

Splices in bus bars shall be permitted.

Exception No. 2:

Where a service consists of more than a single enclosure, it shall be permissible to connect taps to the grounding electrode conductor. Each such tap conductor shall extend to the inside of each such enclosure.

- 9.7.1.2 The equipment grounding conductor run with or enclosing the circuit conductors shall be 1 or more or a combination of the following:

- (1) Copper or other corrosion-resistant conductor. This conductor shall be solid or stranded, insulated, covered, or bare; and in the form of a wire or a busbar of any shape;
- (2) rigid metal conduit;
- (3) intermediate metal conduit;
- (4) electrical metallic tubing;
- (5) flexible metal conduit approved for the purpose and installed with fittings approved for the purpose;
- (6) armour of metal-clad cable;
- (7) the sheath of mineral-insulated metal-sheathed cable;
- (8) metallic cable trays;
- (9) the sheath of copper-sheathed or aluminum-sheathed cable;
- (10) other raceways specifically approved for grounding purposes.

Exception No. 1:

Flexible metal conduit shall be permitted for grounding if all the following conditions are met:

- (1) The length does not exceed 2 m.
- (2) The circuit conductors contained therein are protected by overcurrent devices rated at 20 amperes or less.
- (3) The conduit is terminated in fittings approved for the purpose.

Exception No. 2:

Liquidtight flexible metal conduit shall be permitted for grounding in the 36 mm and smaller trade sizes if the length is 2 m or less and the conduit is terminated in fittings approved for the purpose.

Exception No. 3:

For direct-current circuits only, the equipment grounding conductor shall be permitted to be run separately from the circuit conductors.

- 9.7.1.3 Supplementary grounding electrodes shall be permitted to augment the equipment grounding conductors specified in item 9.7.1.2, but the earth shall not be used as the sole equipment grounding conductor.

9.7.2 **Installation**

Grounding conductors shall be installed as specified in items 9.7.2.1 and 9.7.2.2 below.

- 9.7.2.1 A grounding electrode conductor or its enclosure shall be securely fastened to the surface on which it is carried. A 25 sq mm or larger conductor shall be protected if exposed to severe physical damage. A 16 sq mm grounding conductor that is free from exposure to physical damage shall be permitted to be run along the surface of the building construction without metal covering or protection where it is rigidly fastened to the construction; otherwise, it shall be in rigid metal conduit, intermediate metal conduit, electrical metallic tubing, or cable armour. Grounding conductors smaller than 16 sq mm shall be in rigid metal conduit, intermediate metal conduit, electrical metallic tubing, or cable armour.

Metal enclosures for grounding conductors shall be electrically continuous from the point of attachment to cabinets or equipment to the grounding electrode, and shall be securely fastened to the ground clamp or fitting. Metal enclosures that are not physically continuous from cabinet or equipment to the grounding electrode shall be made electrically continuous by bonding each end to the grounding conductor.

Aluminum or copper-clad aluminum grounding conductors shall not be used where in direct contact with masonry or the earth or where subject to corrosive conditions. Where used outside, aluminum or copper-clad aluminum grounding conductors shall not be installed within 50 cm of the earth.

- 9.7.2.2 An equipment grounding conductor shall be installed as indicated in items 9.7.2.2.1 and 9.7.2.2.2, below.
- 9.7.2.2.1 Where it consists of a raceway, cable tray, cable armour, or cable sheath or where it is a wire within a raceway or cable, it shall be installed in accordance with the applicable provisions in Section 7.0 using fittings for joints and terminations approved for use with the type raceway or cable used. All connections, joints, and fittings shall be securely fastened using suitable tools.
- 9.7.2.2.2 Where it is separate grounding conductor or by special permission as provided in item 9.4.5.3, it shall be installed in accordance with item 9.7.2.1 in regard to restrictions for aluminum and also in regard to protection from physical damage.

Exception:

Sizes smaller than 16 sq mm shall not be required to be enclosed in a raceway or armour where run in the hollow spaces of a wall or partition or where otherwise installed so as not to be subject to physical damage.

9.7.3 **Size of Equipment Grounding Conductors**

The size of copper, aluminum, or copper-clad aluminum equipment grounding conductors shall not be less than given in Table 3. Where conductors are run in parallel in multiple raceways, the equipment grounding conductor, where used, shall be run in parallel. Each parallel equipment grounding conductor shall be sized on the basis of the ampere rating of the overcurrent device protecting the circuit conductors in the raceway in accordance with Table 3.

When conductors are adjusted in size to compensate for voltage drop, grounding conductors, where required, shall be adjusted proportionately in size.

Exception No. 1:

An equipment grounding conductor not smaller than the circuit conductors if an

integral part of an approved flexible cord assembly shall be permitted for grounding cord-connected equipment where the equipment is protected by overcurrent devices not exceeding 20 ampere rating.

Exception No. 2:

The equipment grounding conductor shall not be required to be larger than the circuit conductors supplying the equipment.

Table 2
Grounding Electrode Conductor For AC System

Size of Largest Service-Entrance Conductor or Equivalent for Parallel Conductors		Size of Grounding Electrode Conductor	
(All Sizes in sq mm)			
Copper	Aluminum or Copper-Clad Aluminum	Copper	Aluminum or Copper-Clad Aluminum
35 or smaller	50 or smaller	10	15
40 or 50	70 or 95	15	20
70 or 95	120 or 129	20	35
Over 95 thru 185	Over 129 thru 258	35	50
Over 185 thru 300	Over 258 thru 460	50	95
Over 300 thru 560	Over 460 thru 890	70	120
Over 560	Over 890	95	129

Where there are no service-entrance conductors, the grounding electrode conductor size shall be determined by the equivalent size of the largest service-entrance conductor required for the load to be served.

9.7.4 Grounding Conductor in Common Raceway

A grounding conductor shall be permitted in the same raceway or enclosure with other conductors of the system to which it is connected.

9.7.5 Grounding Conductor Continuity

Separable connections such as those provided in draw-out equipment or attachment plugs and mating connectors and receptacles shall provide for first-make, last-break of the equipment grounding conductor. No switches shall be placed in the grounding conductor circuit.

9.8 Grounding Conductor Connections

9.8.1 To Raceway or Cable Armour

The point of connection of the grounding conductor to interior metal raceways, cable armour, and the like shall be as near as practicable to the source of supply

and shall be so chosen that no raceway or cable armour is grounded through a run of smaller size than called for in item 9.7.3.

9.8.2 To Grounding Electrode

The connection of a grounding electrode conductor to a grounding electrode shall be accessible and made in a manner that will assure a permanent and effective ground. Where necessary to assure this for a metal piping system used as a grounding electrode, effective bonding shall be provided around insulated joints and sections and around any equipment that is likely to be disconnected for repairs or replacement.

Exception:

A connection to a concrete encased, driven, or buried grounding electrode shall not be required to be accessible.

9.8.3 To Conductors and Equipment

Required grounding conductors and bonding jumpers shall be connected by pressure connectors, clamps, or other approved means. Connection devices or fittings that depend on solder shall not be used.

9.8.4 Continuity and Attachment of Branch-Circuit Equipment Grounding Conductors to Boxes

Where more than 1 equipment grounding conductor of a branch circuit enters a box, all such conductors shall be in good electrical contact with each other and the arrangement shall be such that the disconnection or removal of a receptacle, fixture, or other device fed from the box will not interfere with or interrupt the grounding continuity.

9.8.4.1 A connection shall be made between the 1 or more equipment grounding conductors and a metal box by means of a grounding screw which shall be used for no other purpose, or an approved grounding device.

9.8.4.2 One or more equipment grounding conductors brought into a nonmetallic outlet box shall be so arranged that a connection can be made to any fitting or device in that box requiring grounding.

Table 3
Size of Equipment Grounding Conductors for
Grounding Raceway and Equipment

Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Not Exceeding (Amperes)	Size in (sq mm)	
	Copper Wire Size	Aluminum or Copper-Clad Aluminum Wire Size
15	2	4
20	4	6
30	6	8
40	6	8
60	6	8
100	8	15
200	15	20
400	25	40
600	40	70
800	50	95
1000	70	120
1200	95	129
1600	120	185
2000	129	193
2500	185	300
3000	193	300
4000	258	410
5000	360	610
6000	410	610

9.8.5 Connection to Electrodes

The grounding conductor shall be connected to the grounding fitting by suitable lugs, pressure connectors, clamps, or other approved means. Connections depending on solder shall not be used. Ground clamps shall be suitable for the materials of the grounding electrode and the grounding electrode conductor. Not more than 1 conductor shall be connected to the grounding electrode by a single clamp or fitting unless the clamp or fitting is approved for the use. One of the methods indicated in items 9.8.5.1, 9.8.5.2, 9.8.5.3, or 9.8.5.4 below shall be used.

9.8.5.1 An approved bolted clamp of cast bronze, brass, plain, or malleable iron.

9.8.5.2 A pipe fitting, pipe plug, or other approved device screwed into a pipe or pipe fitting.

9.8.5.3 A sheet-metal-strap type ground clamp having a rigid metal base that seats on the electrode and having a strap of such material and dimensions that it is not likely to stretch during or after installation.

9.8.5.4 Any equally substantially approved means.

9.8.6 Protection of Attachment

Ground clamps or other fittings shall be approved for general use without protection or shall be protected from ordinary physical damage.

9.8.7 Clean Surfaces

Nonconductive coatings (such as paint, lacquer, and enamel) on equipment to be grounded shall be removed from threads and other contact surfaces to assure good electrical continuity.

9.9 Instrument Transformers, Relays, Etc.**9.9.1 Instrument Transformer Cases**

Cases or frames of instrument transformers shall be grounded where accessible to other than qualified persons.

Exception:

Cases or frames of current transformers, the primaries of which are not over 150 volts to ground and which are used exclusively to supply current to meters.

9.9.2 Cases of Instruments, Meters, and Relays - Operating at 600 Volts or Less

Instruments, meters, and relays operating with windings or working parts at 600 volts or less shall be grounded as specified in items 9.9.2.1, 9.9.2.2, or 9.9.2.3 below.

9.9.2.1 Instruments, meters, and relays not located on switchboards, operating with windings or working parts at 300 volts or more to ground, and accessible to other than qualified persons, shall have the cases and other exposed metal parts grounded.

9.9.2.2 Instruments, meters, and relays (whether operated from current and potential transformers, or connected directly in the circuit) on switchboards having no live parts on the front of the panels shall have the cases grounded.

9.9.2.3 Instruments, meters, and relays (whether operated from current and potential

transformers, or connected directly in the circuit) on switchboards having exposed live parts on the front of panels shall not have their cases grounded. Mats of insulating rubber or other suitable floor insulation shall be provided for the operator where the voltage to ground exceeds 150.

- 9.9.3 The grounding conductor for instrument cases shall not be smaller than 4.0 sq mm copper or equivalent. Cases of instrument transformers, instruments, meters, and relays which are mounted directly on grounded metal surfaces of enclosures or grounded metal switchboard panels shall be considered to be grounded and no additional grounding conductor will be required.

10. WIRING METHODS

10.1 General Requirements for Wiring Methods

The provisions of this item 10 shall apply to all wiring installations except for remote control, low-energy power and signal systems and communication systems, and are not intended to apply to the conductors which form an integral part of equipment, such as motors, controllers, motor control centers, or factory-assembled equipment.

10.2 Voltage Limitations

Wiring methods specified in items 10 through 16, shall be used for voltages not exceeding 600 volts where not specifically limited. They shall be permitted for voltages over 600 volts where specifically permitted elsewhere in Section 7.0.

10.3 Conductors of Different Systems

- 10.3.1 Conductors of different systems of 600 volts or less shall be permitted to occupy the same enclosure, without regard to whether the individual circuits are alternating current or direct current, where all conductors are insulated for the maximum voltage of any conductor within the enclosure.
- 10.3.2 Conductors of different systems of over 600 volts shall not occupy the same enclosure with conductors of light and power systems of 600 volts or less.
- 10.3.3 Secondary wiring to electric-discharge lamps of 1000 volts or less, if insulated for the secondary voltage involved, shall be permitted to occupy the same fixture enclosure as the branch-circuit conductors.
- 10.3.4 Primary leads of electric-discharge lamp ballasts, insulated for the primary voltage of the ballasts, when contained within the individual wiring enclosure, shall be permitted to occupy the same fixture enclosure as the branch-circuit conductors.
- 10.3.5 Excitation, control, relay, and ammeter conductors used in connection with any individual motor or starter shall be permitted to occupy the same enclosure as the motor circuit conductors.
- 10.3.6 Where 2 or more service switches or circuit breakers are mounted in an approved grouped service enclosure which is supplied by a single set of service entrance conductors, the conductors on the load side of the different service switches may be run in a common wiring space inside the service enclosure, without barriers, provided the conductors of each individual system are cabled or banded together

and identified in a suitable manner.

10.4 **Grounding Metal Enclosures**

Metal raceways, boxes, cabinets, cable armour, and fittings shall be grounded as required in item 9.

10.5 **Electrical Continuity of Metal Raceways and Enclosures**

Metal Raceways, cable armour, and other metal enclosures for conductors shall be metallically joined together into a continuous electric conductor, and shall be so connected to all boxes, fittings, and cabinets as to provide effective electrical continuity. Raceways and cable assemblies shall be mechanically secured to boxes, fittings, cabinets, and other enclosures.

10.6 **Secured in Place**

Raceways, cable assemblies, boxes, cabinets, and fittings shall be securely fastened in place, unless otherwise provided for specific purposes elsewhere in Section 7.0.

10.7 **Induced Currents in Metal Enclosures or Metal Raceways**

Where conductors carrying alternating current are installed in metal enclosures or metal raceways, they shall be so arranged as to avoid heating the surrounding metal by induction. To accomplish this, all phase conductors and, where used, the neutral and all equipment grounding conductors shall be grouped together.

11. **TEMPORARY WIRING**

11.1 **Scope**

The provisions of this item 11 apply to temporary electrical power and lighting wiring methods which may be of a class less than would be required for a permanent installation. Except as specifically modified in this item 11, all other requirements of Section 7.2 for permanent wiring shall apply to temporary wiring installations.

Temporary electrical power and lighting installations shall be permitted during the period of construction, remodeling, maintenance, repair, or demolition of buildings, structures, equipment or similar activities.

11.2 **General**

11.2.1 **Feeders**

Feeders shall originate in an approved distribution center. The conductors shall be permitted within multi-conductor cord or cable assemblies or where not subject to mechanical injury, they shall be permitted to be run as open conductors on insulators not more than 3 m apart.

11.2.2 **Branch Circuits**

All branch circuits shall originate in an approved power outlet or panelboard. Conductors shall be permitted within multi-conductor cord or cable assemblies or as open conductors. When run as open conductors they shall be fastened at ceiling height every 3 m. No conductor shall be laid on the floor. Each branch circuit that supplies receptacles or fixed equipment shall contain a separate

equipment grounding conductor when run as open conductors.

11.2.3 Receptacles

All receptacles shall be of the grounding-type. Unless installed in a complete metallic raceway all branch circuits shall contain a separate equipment grounding conductor and all receptacles shall be electrically connected to the grounding conductor.

11.2.4 Earth Returns

Earth returns shall not be used for the wiring of temporary circuits.

11.2.5 Disconnecting Means

Suitable disconnecting switches shall be installed to permit the disconnection of all ungrounded conductors of each temporary circuit.

11.2.6 Lamp Protection

All lamps for general illumination shall be protected from accidental contact or breakage. Protection shall be provided by elevation of at least 2.2 m from normal working surface or by a suitable fixture or lampholder with a guard.

11.3 Grounding

All grounding shall conform with item 9.

12. CONDUCTORS FOR GENERAL WIRING

12.1 Scope

This item 12 covers general requirements for conductors. These requirements do not apply to conductors that form an integral part of equipment, such as motors, motor controllers, and similar equipment or to conductors specifically provided for elsewhere in Section 7.0.

12.2 Conductors to be Insulated

Conductors shall be insulated unless covered or bare conductors are specifically permitted elsewhere in Section 7.0.

12.3 Marking

All insulated conductors and cables shall be marked by a suitable method to indicate the maximum working voltage for which the conductor was tested or approved, identifying letters for the type of insulation, and the size of the conductor.

13. CABLE TRAYS

13.1 Scope

A cable tray system is a unit or assembly of units or sections, and associated fittings, made of metal or other noncombustible materials forming a rigid structural system used to support cables. Cable tray systems include ladders, troughs, channels, solid bottom trays, and other similar structures.

13.2 Grounding

Metallic cable trays which support electrical conductors shall be grounded.

14. OPEN WIRING

Open exposed wiring shall not be installed in any building or portion of a building except in substations, transformer vaults, transformer enclosures, for the supply of electric furnace electrodes, or in tunnels or similar locations, where such spaces are restricted to electrical use and are accessible to qualified and authorized persons only.

15. SWITCHES**15.1 Enclosures**

Switches shall comply with the following: All manually operated switches shall be enclosed in boxes or cabinets, except where other types are specifically permitted by Section 7.0. Switches are not required to be of the enclosed box or cabinet types when operating at 50 volts or less; as for example, in some electric furnace and electrolytic installations. In such cases the switches shall be protected by suitable guards or enclosures if they are exposed to danger of short circuiting or accidental contact. Pendant type and surface-type snap switches and knife switches mounted on an open-face switchboard or panelboard are not required to be enclosed in boxes or cabinets.

15.2 Position of Knife Switches

Single-throw knife switches shall be so placed that gravity will not tend to close them. Double-throw knife switches shall be permitted to be mounted so that the throw will be either vertical or horizontal. Where the throw is vertical, a locking device shall be provided that will insure the blades remaining in the open position when so set.

15.3 Connection of Knife Switches

Single-throw knife switches shall be so connected that the blades are dead when the switch is in the open position.

15.4 Accessibility and Grouping

All switches and circuit breakers used as switches shall be located that they may be operated from a readily accessible place. They shall be so installed that the center of the grip of the operating handle of the switch or circuit breaker, when in its highest position, will not be more than 2 m above the floor or working platform.

Exception No. 1:

On busway installations, fused switches and circuit breakers shall be permitted to be located at the same level as the busway. Suitable means shall be provided to operate the handle of the device from the floor.

Exception No. 2:

Switches installed adjacent to motors, appliances or other equipment which they

supply shall be permitted to be located higher than specified in the foregoing and to be accessible by portable means.

Exception No. 3:

Hotstick operable isolating switches shall be permitted in heights of more than 2 m.

15.5 Capacity

Switches and circuit breakers shall have an ampere rating not less than the ampere rating of the load unless a demand factor shall have been granted. They shall have a voltage rating not less than the nominal operating voltage of the circuit controlled by the switch or circuit breaker.

15.6 Grounding of Enclosures

Enclosures for switches on circuits of over 50 volts to ground shall be grounded. Where nonmetallic enclosures are used with metal sheathed cables or metallic conduits, provisions shall be made for grounding continuity of the cable sheath or conduit.

15.7 Signs

Unless so interlocked that they cannot be opened under load, isolating switches shall be provided with permanent warning signs legible at 4 m reading substantially as follows:

"Disconnecters - Do Not Open Under Load"

16. SWITCHBOARDS AND PANELBOARDS

16.1 Supporting and Arrangement of Busbars and Conductors

16.1.1 Conductors and busbars on a switchboard, panelboard, or control board shall be so located as to be free from physical damage and shall be held firmly in place. Other than the required interconnections and control wiring, only those conductors that are intended for termination in a vertical section of a switchboard shall be located in that section. Barriers shall be placed in all service switchboards that will isolate the service busbars and terminals from the remainder of the switchboard.

16.1.2 Load terminals in switchboards and panelboards shall be so located that it will be unnecessary to reach across or beyond an ungrounded line bus in order to make load connections.

16.1.3 On a switchboard or a panelboard supplied from a 4-wire delta-connected system, where the mid-point of 1 phase is grounded, that phase busbar or conductor having the higher voltage to ground shall be marked.

16.1.4 The phase arrangement on 3-phase buses shall be A, B, C from front to back, top to bottom, or left to right, as viewed from the front of the switchboard or panelboard. The B phase shall be that phase having the higher voltage to ground. Other busbar arrangements shall be permitted for additions to existing installations and shall be marked.

16.2 Location of Switchboards

Switchboards that have any exposed live parts shall be located in permanently dry locations and then only where under competent supervision and accessible only to qualified persons.

16.3 Grounding

Switchboard frames and structures supporting switching equipment and panelboard cabinets shall be grounded.

17. FLEXIBLE CORDS AND CABLES**17.1 Uses Permitted**

Flexible cords and cables shall be used only for (1) pendants; (2) wiring of fixtures; (3) connection of portable lamps or appliances; (4) elevator cables; (5) wiring of cranes and hoists; (6) connection of stationary equipment to facilitate their frequent interchange; or (7) prevention of the transmission of noise or vibration; or (8) appliances where the fastening means and mechanical connections are designed to permit removal for maintenance and repair; or (9) data processing cables.

Where used as permitted in items (3), (6), and (8), each flexible cord shall be equipped with an attachment plug and shall be energized from an approved receptacle outlet.

17.2 Uses Not Permitted

Flexible cords and cables shall not be used (1) as a substitute for the fixed wiring of a structure; (2) where run through holes in walls, ceilings, or floors; (3) where run through doorways, windows or similar openings; (4) where attached to building surfaces; or (5) where concealed behind building walls, ceilings, or floors.

17.3 Splices

Flexible cord shall be used only in continuous lengths without splice or tap when initially installed. The repair of flexible cords shall be permitted if the completed splice retains the insulation, outer sheath properties, and usage characteristics of the cord being spliced.

17.4 Grounding-Conductor Identification

A conductor intended to be used as a grounding conductor shall have a continuous identifying marker readily distinguishing it from the other conductor or conductors.

18. LIGHTING FIXTURES, LAMPHOLDERS, LAMPS, AND RECEPTACLES**18.1 Live Parts**

Fixtures, lampholders, lamps, and receptacles shall have no live parts normally exposed to contact. Exposed accessible terminals in lampholders, receptacles, and switches shall not be installed in metal fixture canopies or in open bases of

portable table or floor lamps.

18.2 **Wet and Damp Locations**

Fixtures installed in wet or damp locations shall be approved for the purpose and shall be so constructed or installed that water cannot enter or accumulate in wireways, lampholders, or other electrical parts.

18.3 **Outlet Boxes to be Covered**

In a completed installation, each outlet box shall be provided with a cover unless covered by means of a fixture canopy, lampholder, receptacle, or similar device.

18.4 **Grounding**

18.4.1 **Exposed Fixture Parts**

The exposed conductive parts of lighting fixtures and equipment directly wired or attached to outlets supplied by a wiring method which provides an equipment ground shall be grounded.

Fixtures directly wired or attached to outlets supplied by a wiring method which does not provide a ready means for grounding shall be made of insulating material and shall have no exposed conductive parts.

18.4.2 **Equipment Over 150 Volts to Ground**

Metal fixtures, transformers, and transformer enclosures on circuits operating at over 150 volts to ground shall be grounded. Other exposed metal parts shall be either grounded or insulated from ground and other conducting surfaces and inaccessible to unqualified persons.

Exception:

Lamp tie wires, mounting screws, clips, and decorative bands on glass lamps spaced not less than 4 cm from lamp terminals shall not be required to be grounded.

18.4.3 **Methods of Grounding**

Equipment shall be considered grounded where mechanically connected in a permanent and effective manner to metal raceway, the armor of armored cable, the metallic sheath of mineral-insulated metal-sheathed cable, the grounding conductor in nonmetallic-sheathed cable, or to a separate grounding conductor sized in accordance with Table 3, provided that the raceway, armour sheath, or grounding conductor is grounded in a manner specified in item 9.

18.5 **Polarization of Fixtures**

Fixtures shall be so wired that the screw-shells of lampholders will be connected to the same fixture or circuit conductor or terminal. The identified grounded conductor, where connected to a screw-shell lampholder, shall be connected to the screw-shell.

18.6 **Construction of Fixtures**

18.6.1 **Fixture Rating**

All fixtures requiring ballasts or transformers shall be plainly marked with their electrical rating which shall include the voltage and frequency and shall indicate

the current rating of the unit, including the ballast, transformer, or auto-transformer.

18.6.2 **Portable Lamps**

18.6.2.1 Portable lamps shall be wired with flexible cord, approved for the purpose and polarized or grounding type attachment plugs, shall be used.

18.6.2.2 In addition to the provisions of item 18.6.2.1, portable handlamps shall comply with the following: (1) Metal shell, paperlined lampholders shall not be used; (2) Handlamps shall be equipped with a handle of molded composition or other material approved for the purpose; (3) Handlamps shall be equipped with a substantial guard attached to the lampholder or handle; (4) Metallic guards shall be grounded by means of an equipment grounding conductor run with circuit conductors within the power supply cord.

18.6.3 **Tests**

All wiring shall be free from short circuits and grounds and shall be tested for these defects prior to being connected to the circuit.

18.6.4 **Live Parts**

Exposed live parts within porcelain fixtures shall be suitably recessed and so located as to make it improbable that wires will come in contact with them. There shall be a spacing of at least 13 mm between live parts and the mounting plane of the fixture.

18.7 **Construction of Lampholders**

The outer metal shell and the cap shall be lined with insulating material which shall prevent the shell and cap from becoming a part of the circuit. The lining shall not extend beyond the metal shell more than 3 mm, but shall prevent any current-carrying part of the lamp base from being exposed when a lamp is in the lampholding device.

18.8 **Receptacles, Adapters, Cord Connectors and Attachment Plugs**

18.8.1 **Rating and Type**

18.8.1.1 Receptacles installed for the attachment of portable cords shall be rated at not less than standards approved by GSMO and shall be of a type not suitable for use as lampholders.

18.8.1.2 All 15 and 20 ampere attachment plugs and connectors shall be so constructed that there are no exposed current-carrying parts except the prongs, blades, or pins. The cover for wire terminations shall be a part which is essential for the operation of an attachment plug or connector (dead-front construction).

18.8.1.3 Receptacles, cord connectors and attachment plugs shall be constructed so that the receptacle or cord connectors will not accept an attachment plug with a different voltage or current rating than that for which the device is intended. Nongrounding type receptacles and connectors shall not accept grounding type attachment plugs.

18.8.2 **Grounding-Type Receptacles, Adapters, Cord Connectors, and Attachment Plugs**

18.8.2.1 Grounding-type receptacles, cord connectors, and attachment plugs shall be

provided with 1 fixed grounding pole in addition to the circuit poles.

18.8.2.2 Grounding-type receptacles, adapters, cord connectors, and attachment plugs shall have a means for connection of a grounding conductor to the grounding pole. A terminal for connection to the grounding pole shall be distinctively marked.

18.8.2.3 A grounding terminal or grounding-type device shall not be used for purposes other than grounding. Two pole to 3 pole adapters shall not be used. Adapters permitting change to different rated (amperes or volts) configurations shall not be used.

Exception:

15-amp receptacles shall be permitted to supply 20-amp adapters.

19. APPLIANCES

19.1 General

Appliances shall have no live parts normally exposed to contact.

Exception:

Toasters, grills or other appliances in which the current-carrying parts at high temperature are necessarily exposed.

19.2 Installation of Appliances

19.2.1 General

All appliances shall be installed in an approved manner.

19.2.2 Portable Immersion Heaters

Electric heaters of the portable immersion type shall be so constructed and installed that current-carrying parts are effectively insulated from electrical contact with the substance in which they are immersed. The authority having jurisdiction may make exceptions for special applications of apparatus if suitable precautions are taken.

19.2.3 Storage and Instantaneous Type Water Heaters

Each storage or instantaneous-type water heater shall be equipped with a temperature limiting means in addition to its control thermostat to disconnect all ungrounded conductors, and such means shall be: (1) installed to sense maximum water temperature; (2) either a trip-free, manually reset type or a type having a replacement element. Such water heaters shall be marked to require the installation of a pressure relief valve.

Exception:

Water heaters with supply water temperature of 80°C or above and a capacity of 60 kw or above, and water heaters with a capacity of 4 liters or less, approved for the purpose.

19.2.4 Infrared Lamp Industrial Heating Appliances

19.2.4.1 Infrared heating lamps rated at 300 watts or less shall be permitted with lampholders of the medium-base, unswitched porcelain type or other types approved for the purpose.

- 19.2.4.2 Screw shell lampholders shall not be used with infrared lamps over 300 watts rating, unless approved for the purpose.
- 19.2.4.3 Lampholders shall be permitted to be connected to branch circuits, and shall be permitted to be operated in series on circuits of over 150 volts to ground provided the voltage rating of the lampholders is not less than the circuit voltage.
- 19.2.4.4 Each section, panel, or strip carrying a number of infrared lampholders (including the internal wiring of such section, panel, or strip) shall be considered an appliance. The terminal connection block of each such assembly shall be considered an individual outlet.
- 19.2.5 **Grounding**
- Metal frames of electrically heated appliances, operating on circuits over 150 volts to ground, shall be grounded.
- 19.3 **Control and Protection of Appliances**
- 19.3.1 **Disconnection of Permanently Connected Appliances**
- 19.3.1.1 For permanently connected appliances rated at not over 300 volt-amperes or 1/8 hp, the branch circuit overcurrent device shall be permitted to serve as the disconnecting means.
- 19.3.1.2 For permanently connected appliances the branch circuit switch or circuit breaker may, where readily accessible to the user of the appliance, serve as the disconnecting means.
- 19.3.2 **Disconnection of Cord and Plug Connected Appliances**
- 19.3.2.1 For cord and plug connected appliances, a separable connector or an attachment plug and receptacle shall be permitted to serve as the disconnecting means.
- 19.3.2.2 The rating of a receptacle or of a separable connector shall not be less than the rating of any appliance connected thereto.
- 19.3.2.3 Attachment plugs and connectors shall conform to the provisions of items 19.3.2.3.1 through 19.3.2.3.3 below.
- 19.3.2.3.1 They shall be so constructed and installed as to guard against inadvertent contact with live parts.
- 19.3.2.3.2 They shall be capable of interrupting their rated current without hazard to the operator.
- 19.3.2.3.3 They shall be so designed that they will not fit into receptacles of lesser rating.
- 19.3.3 **Disconnecting Means for Motor-Driven Appliances**
- If a switch or circuit breaker serves as the disconnecting means for a stationary or fixed motor-driven appliance of more than 1/8 hp, it shall be located within sight from the motor controller and shall comply with the disconnecting means specified in item 22.
- 19.4 **Marking of Appliances**
- 19.4.1 Each electric appliance shall be provided with a nameplate, giving the identifying name and the rating in volts and amperes, or in volts and watts. If the appliance is to be used on a specific frequency or frequencies, it shall be so marked.

- 19.4.1.1 When motor overload protection external to the appliance is required, the appliance shall be so marked.
- 19.4.1.2 Marking shall be located so as to be visible or easily accessible after installation.
- 19.4.2 All heating elements that are rated over one ampere, replaceable in the field, and a part of an appliance shall be legibly marked with the ratings in volts and amperes, or in volts and watts.

20. FIXED ELECTRIC SPACE HEATING EQUIPMENT

20.1 Scope

This item 20, covers fixed electric equipment used for space heating. Equipment shall be of a type approved for the purpose and location where installed. For the purpose of this item heating equipment shall include heating cable, unit heaters, boilers, central systems, or other approved fixed electric space heating equipment. This item shall not apply to process heating and room air conditioning.

20.2 Installation

- 20.2.1 All fixed electric space heating equipment shall be installed in an approved manner.
- 20.2.2 All exposed metal parts of fixed electric space heating equipment likely to become energized shall be grounded.
- 20.2.3 Means shall be provided to disconnect the heater, controller(s), and overcurrent protective device(s) of all fixed electric space heating equipment from all ungrounded conductors.
- 20.2.4 Switches and circuit breakers used as disconnecting means shall be of the indicating type.

20.3 Marking of Heating Equipment

20.3.1 Nameplate

- 20.3.1.1 Each unit of fixed electric space heating equipment shall be provided with a nameplate giving the identifying name and the normal rating in volts and watts, or in volts and amperes.

Electric space heating equipment intended for use on alternating current only or direct current only shall be marked to so indicate. The marking of equipment consisting of motors and other loads shall specify the rating of the motor in volts, amperes, and frequency, and the heating load in volts and watts, or in volts and amperes.

- 20.3.1.2 This nameplate shall be located so as to be visible or easily accessible after installation.

20.3.2 Marking of Heating Elements

All heating elements that are replaceable in the field and are a part of an electric heater shall be legibly marked with the ratings in volts and watts, or in volts and amperes.

20.4 Duct Heaters

- 20.4.1 This item 20.4 shall apply to any heater mounted in the air stream of a forced-air system where the air moving unit is not provided as an integral part of the equipment.
- 20.4.2 Heaters installed in an air duct shall be approved for the purpose and installed in the approved manner.
- 20.4.3 Duct heater controller equipment shall be accessible with the disconnecting means installed at or within sight from the controller.

Exception:

The disconnecting means shall be arranged to be locked in the "open" position if it is not within sight of the controller. A distance more than 15 m shall be considered as equivalent to being out of sight.

- 20.4.4 Duct heaters shall be installed in accordance with the manufacturer's instructions in a manner so that operation will not create a hazard to persons. Furthermore, duct heaters shall be located with respect to building construction and other equipment so as to permit access to the heater. Sufficient clearance shall be maintained to permit replacement of controls and heating elements and for adjusting and cleaning of controls and other parts requiring such attention.

20.5 Resistance-Type Boilers

- 20.5.1 The provisions in this item 20.5, shall apply to boilers employing resistance-type heating elements. Electrode-type boilers shall not be considered as employing resistance-type heating elements.
- 20.5.2 Resistance-type boilers shall be approved for the purpose and installed in the approved manner.
- 20.5.3 All exposed noncurrent carrying metal parts shall be grounded. Means for connection of equipment grounding conductor(s) sized in accordance with Table 3 shall be provided.

20.6 Electrode-Type Boilers

- 20.6.1 The provisions in this item shall apply to boilers for operation at 600 volts or less in which heat is generated by the passage of current between electrodes through the liquid being heated.
- 20.6.2 Electrode-type boilers shall be approved for the purpose and installed in the approved manner.
- 20.6.3 All exposed noncurrent carrying metal parts including the supply and return connecting piping shall be grounded. The vessel containing the electrodes shall be isolated and electrically insulated from the ground.
- 20.6.4 All electrode-type boilers shall be marked to show: (1) the normal rating in volts, amperes and kilowatts; (2) the electrical supply required specifying frequency, number of phases and number of wires; (3) the marking "Electrode-Type Boiler"; (4) a warning marking - "ALL POWER SUPPLIES SHALL BE DISCONNECTED BEFORE SERVICING INCLUDING SERVICING THE PRESSURE VESSEL".

The nameplate shall be located so as to be visible after installation.

21. FIXED ELECTRIC HEATING EQUIPMENT FOR PIPE-LINES AND VESSELS

21.1 Definitions

For the purpose of this item:

An Integrated Heating System is a complete system consisting of components such as pipelines, vessels, heating elements, heat transfer controller, safety signs, junction boxes, conduit and fittings.

A Pipeline is a length of pipe including pumps, valves, flanges, control devices, strainers and/or similar equipment for conveying fluids.

A Vessel is a container such as a barrel, drum, or tank for holding fluids or other material.

21.2 Scope

The requirements of this item 21 shall apply to electrically energized heating systems and the installation of these systems used with pipelines and/or vessels. This article covers electrical heating of pipelines and/or vessels by separate external heating elements, other than the skin electric current tracing or impedance methods.

21.3 Marking

The presence of electric pipeline and vessel heating equipment shall be evident by the posting of appropriate signs or other markings at frequent intervals in the area involved.

21.4 Control and Protection

21.4.1 Means shall be provided to disconnect all fixed electric pipeline or vessel heating equipment from all ungrounded conductors. The branch circuit switch or circuit breaker, where readily accessible to the user of the equipment, shall be permitted to serve as the disconnecting means. Switches used as disconnecting means shall be of the indicating type, and shall be provided with a positive lockout in the "off" position.

21.4.2 The factory installed attachment plug of cord-connected equipment, rated 20 amperes or less and 150 volts or less to ground is an acceptable means of disconnection.

21.4.3 Each factory-assembled heating unit shall be legibly marked within 10 cm of the end of each power supply nonheating lead with the permanent identification symbol, and ratings in volts and watts, or in volts and amperes.

21.4.4 Exposed noncurrent-carrying metal parts of electric heating equipment which are likely to become energized shall be grounded.

22. MOTORS, MOTOR CIRCUIT AND CONTROLLERS

22.1 General

22.1.1 Where item 22 specifies that 1 equipment shall be "in sight from" another

equipment, one of the equipments specified shall be visible and not more than 15 m distant from the other.

- 22.1.2 A motor shall be marked with the rated voltage, full load current and frequency as well as any other pertinent information.
- 22.1.3 A motor-running overload device that can restart a motor automatically after overload tripping shall not be installed unless approved for use with the motor it protects. A motor that can restart automatically after shutdown shall not be installed if its automatic restarting can result in injury to persons.
- 22.1.4 If immediate automatic shutdown of a motor by a motor overload protective device(s) would introduce additional or increased hazard(s) to a person(s) and continued motor operation is necessary for safe shutdown of equipment or process, a motor overload sensing device(s) shall be permitted to be connected to a supervised alarm instead of causing immediate interruption of the motor circuit, so that corrective action or an orderly shutdown can be initiated.

22.2 **Motor Control Circuits**

22.2.1 **Definition**

The circuit of a control apparatus or system that carries the electric signals directing the performance of the controller, but does not carry the main power current.

22.2.2 **Disconnection**

- 22.2.2.1 Motor control circuits shall be so arranged that they will be disconnected from all sources of supply when the disconnecting means is in the "Open" position. The disconnecting means shall be permitted to consist of 2 or more separate devices, 1 of which disconnects the motor and the controller from the source(s) of power supply for the motor, and the other(s), the motor control circuit(s) from their power supply. Where separate devices are used, they shall be located immediately adjacent 1 to each other.

Exception:

Where the opening of 1 or more motor control circuit disconnect means may result in potentially unsafe conditions for personnel, and where all the following conditions are complied with:

- (1) Access to live parts is limited to qualified persons.
 - (2) A warning sign is permanently located on the outside of each disconnecting means permitting access to the live parts in the motor control circuit(s), warning that motor control circuit disconnecting means are remotely located and specifying the location and identification of each disconnect. Where live parts are not in an equipment enclosure, an additional warning sign(s) shall be located where visible to persons who may be working in the area of the live parts.
- 22.2.2.2 Where a transformer or other devices is used to obtain a reduced voltage for the control circuit and is located in the controller, such transformer or other device shall be connected to the load side of the disconnecting means for the control circuit.

22.3 Motor Controllers**22.3.1 Definition**

The term "Controller" includes any switch or device normally used to start and stop a motor.

22.3.2 Motor Not in Sight from Controller

Where a motor and the driven machinery are not in sight from the controller location, the installation shall comply with one of the following conditions:

22.3.2.1 The controller disconnecting means shall be capable of being locked in the "open" position.

22.3.2.2 A manually operable switch that will disconnect the motor from its source of supply shall be placed within sight from the motor location.

22.4 Disconnecting Means

22.4.1 A disconnecting means shall be located in sight from the controller location.

Exception:

A single disconnecting means shall be permitted to be located adjacent to a group of coordinated controllers mounted adjacent 1 to each other on a multi-motor continuous process machine.

22.4.2 The disconnecting means shall disconnect the motor and the controller from all ungrounded supply conductors and shall be so designed that no pole can be operated independently. The disconnecting means shall be permitted in the same enclosure with the controller.

22.4.3 The disconnecting means shall plainly indicate whether it is in the "open" (off) or "closed" (on) position.

22.4.4 Where an installation consists of a single motor, the service switch may serve as the disconnecting means if it complies with this item 22.4, and is within sight from the controller location.

22.4.5 One of the disconnecting means shall be readily accessible.

22.4.6 Each motor shall be provided with an individual disconnecting means.

Exception:

A single disconnecting means shall be permitted to serve a group of motors under any 1 of the following conditions:

- (1) Where a number of motors drive several parts of a single machine or piece of apparatus, such as metal and woodworking machines, cranes, and hoists.
- (2) Where a group of motors is in a single room within sight from the location of the disconnecting means.

22.4.7 Motor and motor-operated equipment receiving electrical energy from more than 1 source shall be provided with disconnecting means from each source of electrical energy immediately adjacent to the equipment served. Each source shall be permitted to have a separate disconnecting means.

Exception:

Where a motor receives electrical energy from more than 1 source, the disconnecting means for the main power supply to the motor shall not be required to be immediately adjacent to the motor provided the controller disconnecting means is capable of being locked in the open position.

22.5 Protection of Live Parts - All Voltages

22.5.1 Item 22.5 specifies that live parts shall be protected in a manner judged adequate to the hazard involved.

22.5.2 Exposed live parts of motors and controllers operating at 50 volts or more between terminals shall be guarded by enclosure or by location against accidental contact as follows:

By installation in a room or enclosure that is accessible only to qualified persons.

By installation on a suitable balcony, gallery, or platform, so elevated and arranged as to exclude unqualified persons.

By elevation 2.5 m or more above the floor.

Exception:

Stationary motors having commutators, collectors, and brush rigging located inside of motor-end brackets and not conductively connected to supply circuits operating at more than 150 volts to ground.

22.5.3 Where live parts of motors or controllers operating at over 150 volts to ground are guarded against accidental contact only by location as specified in item 22.5.2, and where adjustment or other attendance may be necessary during the operation of the apparatus, suitable insulating mats or platforms shall be provided so that the attendant cannot readily touch live parts unless standing on the mats or platforms.

22.6 Grounding

22.6.1 Item 22.6 specifies the grounding of motor and controller frames to prevent a potential above ground in the event of accidental contact between live parts and frames. Insulation, isolation, or guarding are suitable alternatives to grounding of motors under certain conditions.

22.6.2 The frames of stationary motors shall be grounded under any of the following conditions: (1) Where supplied by metal-enclosed wiring; (2) Where in a wet location and not isolated or guarded; (3) If in a hazardous location; (4) If the motor operates with any terminal at over 150 volts to ground.

Where the frame of the motor is not grounded, it shall be permanently and effectively insulated from the ground.

22.6.3 The frames of portable motors that operate at over 150 volts to ground shall be guarded or grounded.

22.6.4 Controller enclosures shall be grounded regardless of voltage.

Exception:

Enclosures attached to ungrounded portable equipment.

22.6.5 Where required, grounding shall be done in the manner specified in item 9.

23. AIR CONDITIONING AND REFRIGERATING EQUIPMENT**23.1 Definition**

Hermetically Sealed Units (Motor-Compressor). A combination consisting of a compressor and motor, both of which are enclosed in the same housing, with no external shaft or shaft seals, the motor operating in the refrigerant.

23.2 Scope

The provisions of this item 23 apply to electric motor-driven air-conditioning and refrigerating equipment.

23.3 Marking on Hermetically Sealed Units

The unit shall be provided with a nameplate which shall give the voltage and frequency as well as other pertinent information.

23.4 Disconnecting Means

23.4.1 A disconnecting means capable of disconnecting air-conditioning and refrigerating equipment including motor-compressors, and controllers, from the circuit feeder shall be provided.

23.4.2 For cord-connected equipment such as room air conditioners, drinking water coolers and beverage dispensers, a separable connector or an attachment plug and receptacle shall be permitted to serve as the disconnecting means.

23.4.3 A disconnecting means shall be located within sight from and readily accessible from the air-conditioning or refrigerating equipment.

23.5 Grounding

All exposed metal parts of air-conditioning and refrigerating equipment likely to become energized shall be grounded.

24. GENERATORS**24.1 Marking**

Each generator shall be provided with a nameplate giving frequency, voltage and current rating as well as other pertinent information.

24.2 Protection of Live Parts

Live parts of generators of more than 150 volts to ground shall not be exposed to accidental contact where accessible to unqualified persons.

24.3 Guards for Attendants

Where necessary for the safety of attendants suitable insulating mats or platforms shall be provided so that the attendant cannot readily touch live parts unless standing on the mats or platforms.

25. TRANSFORMERS**25.1 Guarding****25.1.1 Exposed Live Parts**

Transformers shall be so installed that live parts are guarded in accordance with item 3.3.

25.1.2 Voltage Warning

The operating voltage of exposed live parts of transformer installations shall be indicated by signs or visible markings on the equipment or structures.

25.2 Grounding

Exposed noncurrent-carrying metal parts of transformer installations, including fences, guards, etc., shall be grounded.

25.3 Marking

Each transformer shall be provided with a nameplate giving Class according to that approved by GSMO, rated kilovolt-amperes for each class, frequency, primary and secondary voltage, impedance of transformers 25 kva and larger, and the amount and kind of insulating liquid where used. The rated temperature rise above ambient, polarity and tap changing data including voltage, related amperes and tap position.

26. CAPACITORS**26.1 Enclosing and Guarding**

26.1.1 Capacitors containing more than 12 liters of flammable liquid shall be enclosed in vaults or outdoor fenced enclosures.

26.1.2 Capacitors shall be enclosed, located, or guarded so that persons cannot come into accidental contact or bring conducting materials into accidental contact with exposed energized parts, terminals, or buses associated with them.

Exception:

No additional guarding is required for enclosures accessible only to authorized and qualified persons.

26.2 Drainage of Stored Charge

Capacitors shall be provided with a means of draining the stored charge.

26.2.1 The residual voltage of a capacitor shall be reduced to 50 volts or less within 1 minute after the capacitor is disconnected from the source of supply.

26.2.2 The discharge circuit shall be either permanently connected to the terminals of the capacitor or capacitor bank, or provided with automatic means of connecting it to the terminals of the capacitor bank on removal of voltage from the line. Manual means of switching or connecting the discharge circuit shall not be used.

26.3 Disconnecting Means

A disconnecting means shall be provided in each ungrounded conductor for each

capacitor bank.

Exception:

Where a capacitor is connected on the load side of a motor-running overcurrent device.

26.4

Grounding

Capacitor cases shall be grounded.

Exception:

Where the capacitor units are supported on a structure which is designed to operate at other than ground potential.

26.5

Marking

Each capacitor shall be provided with a nameplate giving the rated voltage, frequency, kilovar or amperes, number of phases, and if filled with a combustible liquid, the amount of liquid in litres. When filled with a nonflammable liquid, the nameplate shall so state. The nameplate shall also indicate if a capacitor has a discharge device inside the case.

27. HAZARDOUS (CLASSIFIED) LOCATIONS

27.1

Definitions

Class 1

Locations in which flammable gases or vapours are, or may be present in the air continuously, intermittently or periodically in quantities sufficient to produce explosive or ignitable mixtures.

Class 2

Locations which are hazardous because of the presence of combustible dust.

Class 3

Locations where easily ignitable fibres or flyings are present but not likely to be in suspension in quantities sufficient to produce ignitable mixtures.

Not Classified

Locations not possessing atmospheres described in Classes 1, 2 and 3.

Groups

Seven groups of substances labeled A thru G. The materials within each group have similar hazardous properties. See Table 4 for Groups A thru D and the description following the table for Groups E, F and G.

Division 1

The nature of a hazardous condition in which the hazard may be present on a continuous basis. The hazard may be an explosive or combustible mixture of chemicals (including dust); the hazard may be caused by an electrically conductive dust. Division 1 also includes hazards which exist on a continuous basis from unclassified materials which the concerned authorities deems

hazardous under existing conditions.

Division 2

The nature of a hazardous location in which the hazard may occur accidentally from any of the 7 Groups of materials but does not normally exist on a continuous basis. Division 2 also includes accidental hazards from unclassified materials which the concerned authorities may deem hazardous under existing conditions.

27.2 Scope

Item 27 through 30 cover locations in which the authority having jurisdiction judges the equipment and wiring to be subject to the conditions indicated by the classifications covered in this item 27. Each room, section, or area (including motor and generator rooms and rooms for the enclosure of control equipment) shall be considered individually in determining its classification.

Exception:

Except as modified in items 27 through 30, all other applicable rules contained in Section 7.2 shall apply to electric equipment and wiring installed in hazardous locations.

For definitions of "approved" and "explosion-proof" as used in these items, see item 7.1.1; "dust-ignition-proof" as defined in item 29.1.

- 27.3** Equipment and associated wiring approved as intrinsically safe shall be permitted in any hazardous (classified) location for which it is approved, and the provisions of item 27 through 30 shall not be considered applicable to such installations. Intrinsically safe equipment and wiring shall not be capable of releasing sufficient electrical or thermal energy under normal or abnormal conditions to cause ignition of a specific hazardous atmospheric mixture in its most easily ignited concentration.

Abnormal conditions shall include accidental damage to any field installed wiring, failure of electrical components, application of over-voltage, adjustment and maintenance operations, and other similar conditions.

- 27.4** All conduit referred to for hazardous locations shall be threaded with a standard taper conduit thread. Such conduit shall be wrench tight to minimize sparking when fault current flows through the conduit system. Where it is impracticable to make a threaded joint tight, a bonding jumper shall be used.

27.5 Special Precaution

Items 27 through 30 require a form of construction of equipment and of installation that will insure safe performance under conditions of proper usage and maintenance.

It is important that inspection authorities and users exercise more than ordinary care with regard to installation and maintenance.

The explosion characteristics of air mixtures of hazardous gases, vapours, or dusts vary with the specific material involved. For Class 1 locations, Group A, B, C, and D, the classification involves determinations of maximum explosion pressure, maximum safe clearance between parts of a clamped joint in an enclosure, and the minimum ignition temperature of the atmospheric mixture. For Class 2 locations,

Groups E, F, and G, the classification involves the tightness of the joints of assembly and shaft openings to prevent entrance of dust in the dust-ignition-proof enclosure, the blanketing effect of layers of dust on the equipment that may cause overheating, electrical conductivity of the dust, and the ignition temperature of the dust. It is necessary, therefore, that equipment be approved not only for the class, but also for the specific group of the gas, vapour, or dust that will be present.

For purposes of testing and approval, various air mixtures (not oxygen enriched) have been grouped on the basis of their hazardous characteristics. For Groups A, B, C, and D, see Table 4.

TABLE 4
Chemicals by Groups

Group A Atmospheres	Group D Atmospheres
Chemical	Chemical
Acetylene	Acetic Acid (glacial)
	Acetone
	Acrylonitrile
	Ammonia - Note ³
	Benzene
	Butane
	1-Butanol (butyl alcohol)
	2-Butanol (secondary butyl alcohol)
	n-Butyl Acetate
	Isobutyl Acetate
	Sec-butyl Alcohol
	Di-isobutylene
	Ethane
	Ethanol (ethyl alcohol)
	Ethyl Acetate
	Ethyl Ecrylate (inhibited)
	Ethylene Diamine (anhydrous)
	Ethylene Dichloride
	Gasoline
	Heptanes
	Hexanes
	Isoprene
	Isopropyl Ether
	Mesityl Oxide
	Methane (nature gas)
	Methanol (methyl alcohol)
	3-Methyl-1-Butanol (isoamyl alcohol)
	Methyl-1-Butanol (isoamyl alcohol)
	Methyl Ethyl Ketone
Group B Atmospheres	
Chemical	
Acronlein (Inhibited)-Note ²	
Butadiene - Note ¹	
Ethylene Oxide - Note ²	
Hydrogen	
Manufactured gases containing more than 30% hydrogen (by volume)	
Propylene oxide - Note ²	
Group C Atmospheres	
Chemical	
Acetaldehyde	
Allyl Alcohol	
n-butyraldehyde	
Carbon Monoxide	

Crotonaldehyde	Methyl Isobutyl Ketone
Cyclopropane	2-Methyl-1-Propanol (isobutyl alcohol)
Diethylamine	2-Methyl-1-Propanol
Diethyl Ether	(tertiary butyl alcohol)
Epichlorohydrin	Petroleum Naphtha - Note ⁴
Ethylene	Octanes
Ethylenimine	Pentanes
Hydrogen Sulfide	1-Pentanol (amyl alcohol)
Morpholine	Propane
2-Nitropropane	1-Propanol (propyl alcohol)
Tetrahydrofuran	2-Propanol (isopropyl alcohol)
Unsymmetrical Dimethyl Hydrazine	Propylene
(UDMH 1, 1-dimethyl	Pyridine
hydrazine)	Styrene
	Toluene
	Vinyl Acetate
	Vinyl Chloride
	Xylenes

Note¹: Group D equipment shall be permitted for this atmosphere if such equipment is isolated in accordance with item 27.5.1 by sealing all conduit.

Note²: Group C equipment shall be permitted for this atmosphere if such equipment is isolated in accordance with item 27.5.1 by sealing all conduit.

Note³: For classification of agents involving ammonia see item 4.1.6.

Note⁴: A saturated hydrocarbon mixture boiling in the range 20-135°C. Also known by the synonyms benzine, ligroin, petroleum ether, or naphtha.

Group E: Atmospheres containing metal dust, including aluminum, magnesium, and their commercial alloys, and other metals of similarly hazardous characteristics.

Group F: Atmospheres containing carbon black, charcoal, coal or coke dusts which have more than 8 percent total volatile material or atmospheres containing these dusts sensitized by other materials so that they present an explosion hazard.

Group G: Atmospheres containing flour, starch, or grain dust.

27.5.1 Approval for Class and Properties

Equipment shall be approved not only for the class of location but also for the explosion properties of the specific gas, vapour, or dust that will be present. In addition, equipment shall not have exposed any surface that operates at a temperature in excess of the ignition temperature of the specific gas, vapour, or dust. The characteristics of various atmospheric mixtures of hazardous gases, vapours, and dusts depend on the specific hazardous material involved.

Equipment that has been approved for a Division 1 location shall be permitted in a Division 2 location of the same class and group.

Where specifically permitted in items 27 through 30, general purpose equipment or equipment in general purpose enclosures shall be permitted to be installed in Division 2 locations if the equipment does not constitute a source of ignition under normal operating conditions.

27.5.2 Marking

Approved equipment shall be marked to show the Class, Group, and operating temperature, or temperature range, based on operation in a 50°C ambient, for which it is approved.

Exception No. 1:

Equipment of the nonheat-producing type, such as junction boxes, conduit, and fittings and equipment of the heat producing-type having a maximum temperature not more than 100°C, shall not be required to have a marked operating temperature or temperature range.

Exception No. 2:

Fixed lighting fixtures marked for use in Class 1, Division 2 locations only, need not be marked to indicate the Group. Since there is no consistent relationship between explosion properties and ignition temperature, the 2 are independent requirements.

27.5.3 Temperature

The temperature marking specified in item 27.5.2 shall not exceed the ignition temperature of the specific gas or vapour to be encountered.

27.6 Class 1 Locations

Class 1 locations are those in which flammable gases or vapours are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures. Class 1 locations shall include those specified in items 27.6.1 and 27.6.2 below.

27.6.1 Class 1, Division 1

A Class 1, Division 1 location is a location:

- (1) In which hazardous concentrations of flammable gases or vapours exist continuously, intermittently, or periodically under normal operating conditions; or
- (2) in which hazardous concentrations of such gases or vapours may exist frequently because of repair or maintenance operations or because of leakage; or
- (3) in which breakdown or faulty operation of equipment or processes might

release hazardous concentrations of flammable gases or vapours, and might also cause simultaneous failure of electric equipment.

This classification usually includes locations where volatile flammable liquids or liquefied flammable gases are transferred from one container to another; interiors of spray booths and areas in the vicinity of spraying and painting operations where volatile flammable solvents are used; locations containing open tanks or vats of volatile flammable solvents; locations containing fat and oil extraction equipment using volatile flammable solvents; portions of cleaning and dyeing plants where hazardous liquids are used; gas generator rooms and other portions of gas manufacturing plants where flammable gas may escape; inadequately ventilated pump rooms for flammable gas or for volatile flammable liquids; the interiors of refrigerators and freezers in which volatile flammable materials are stored in open, lightly stoppered, or concentrations of flammable vapours or gases are likely to occur in the course of normal operations.

27.6.2 **Class 1, Division 2**

A Class 1, Division 2 location is a location:

(1) In which volatile flammable liquids or flammable gases are handled, processed, or used, but in which the hazardous liquids, vapours, or gases will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems, or in case of abnormal operation of equipment; or (2) in which hazardous concentrations of gases or vapours are normally prevented by positive mechanical ventilation, but which might become hazardous through failure or abnormal operation of the ventilating equipment; or (3) that is adjacent to a Class 1, Division 1 location, and to which hazardous concentration of gases or vapours might occasionally be communicated unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided.

This classification usually includes locations where volatile flammable liquids or flammable gases or vapours are used, but which, in the judgment of the authority having jurisdiction, would become hazardous only in case of an accident or of some unusual operating condition. The quantity of hazardous material that might escape in case of accident, the adequacy of ventilating equipment, the total area involved, and the record of the industry or business with respect to explosions or fires are all factors that merit consideration in determining the classification and extent of each location.

Piping without valves, checks, meters, and similar devices would not ordinarily introduce a hazardous condition even though used for hazardous liquids or gases. Locations used for the storage of hazardous liquids or of liquefied or compressed gases in sealed containers would not normally be considered hazardous unless subject to other hazardous conditions also.

Electrical conduits and their associated enclosures separated from process fluids by a single seal or barrier shall be classed as a Division 2 location if the outside of the conduit and enclosure is a nonhazardous location.

27.7 Class 2 Locations

Class 2 locations are those that are hazardous because of the presence of combustible dust. Class 2 locations shall include those specified in items 27.7.1 and 27.7.2 below.

27.7.1 Class 2, Division 1

A Class 2, Division 1 location is a location:

(1) In which combustible dust is or may be in suspension in the air continuously, intermittently, or periodically under normal operating conditions; in quantities sufficient to produce explosive or ignitable mixtures; or (2) where mechanical failure or abnormal operation of machinery or equipment might cause such explosive or ignitable mixtures to be produced, and might also provide a source of ignition through simultaneous failure of electric equipment, operation of protection devices, or from other causes; or (3) in which combustible dusts of an electrically conductive nature may be present.

This classification usually includes the working areas of grain handling and storage plants; rooms containing grinders or pulverizers, cleaners, graders, scalpings, open conveyors or spouts, open bins or hoppers mixers or blenders, automatic or hopper scales, packing machinery, elevator heads and boots, stock distributors, dust and stock collectors (except all metal collectors vented to the outside), and all similar dust-producing machinery and equipment in grain-processing plants, starch plants, sugar-pulverizing plants, malting plants, haygrinding plants, and other occupancies of similar nature; coal-pulverizing plants (except where the pulverizing equipment is essentially dust-tight); all working areas where metal dusts and powders are produced, processed, handled, packed or stored (except in tight containers); and all other similar locations where combustible dust may, under normal operating conditions, be present in the air in quantities sufficient to produce explosive or ignitable mixtures.

Combustible dusts which are electrically nonconductive include dusts produced in the handling and processing of grain and grain products, pulverized sugar and cocoa, dried egg and milk powders, pulverized spices, starch and pastes, potato and woodflour, oil meal from beans and seed, dried hay, and other organic materials which may produce combustible dusts when processed or handled. Electrically conductive nonmetallic dusts include dusts from pulverized coal, coke, carbon black, and charcoal. Dusts containing magnesium or aluminum are particularly hazardous and the use of extreme precaution will be necessary to avoid ignition and explosion.

27.7.2 Class 2, Division 2

A Class 2, Division 2 location is a location in which combustible dust will not normally be in suspension in the air or will not be likely to be thrown into suspension by the normal operation of equipment or apparatus in quantities sufficient to produce explosive or ignitable mixtures, but:

(1) Where deposits or accumulations of such combustible dust may be sufficient to interfere with the safe dissipation of heat from electric equipment or apparatus; or (2) where such deposits or accumulations of combustible dust on, in, or in the vicinity of electric equipment might be ignited by arcs, sparks, or burning material

from such equipment.

Locations where dangerous concentrations of suspended dust would not be likely, but where dust accumulations might form on, or in the vicinity of electric equipment, would include rooms and areas containing only closed spouting and conveyors, closed bins or hoppers, or machines and equipment from which appreciable quantities of dust would escape only under abnormal operating conditions; rooms or areas adjacent to a Class 2, Division 1 location as described in item 27.6.1 and into which explosive or ignitable concentrations of suspended dust might be communicated only under abnormal operating conditions; rooms or areas where the formation of explosive or ignitable concentrations of suspended dust is prevented by the operation of effective dust control equipment; warehouses and shipping rooms where dust-producing materials are stored or handled only in bags or containers; and other similar locations.

27.8 Class 3 Locations

Class 3 locations are those that are hazardous because of the presence of easily ignitable fibers or flyings, but in which such fibers or flyings are not likely to be in suspension in the air in quantities sufficient to produce ignitable mixtures. Class 3 locations shall include those specified in items 27.8.1 and 27.8.2 below.

27.8.1 Class 3, Division 1

A Class 3, Division 1 location is a location in which easily ignitable fibers or materials producing combustible flyings are handled, manufactured, or used.

Such locations usually include some parts of rayon, cotton, and other textile mills; combustible fiber manufacturing and processing plants; cotton gins and cotton seed mills; flax-processing plants; clothing manufacturing plants; woodworking plants; and establishments and industries involving similar hazardous processes or conditions.

Easily ignitable fibers and flyings include rayon, cotton (including cotton linters and cotton waste), sisal or henequen, istle, jute, hemp, tow, cocoa fiber, oakum, baled waste kapok, Spanish moss, excelsior, and other materials of similar nature.

27.8.2 Class 3, Division 2.

A Class 3, Division 2 location is a location in which easily ignitable fibers are stored or handled.

Exception:

In process of manufacture.

28. CLASS 1 LOCATIONS

28.1 General

The general rules of Section 7.0 shall apply to the electric wiring and equipment in locations classified as Class 1 in item 27.6, except as modified by this item 28.

28.2 Transformers and Capacitors

28.2.1 Class 1, Division 1

In Class 1, Division 1 locations, transformers and capacitors shall comply with the

provisions of items 28.2.1.1 and 28.2.1.2 below:

28.2.1.1 Containing Liquid That Will Burn

Transformers and capacitors containing a liquid that will burn shall be installed only in approved vaults and in addition: (1) there shall be no door or other communicating opening between the vault and the hazardous area; and (2) ample ventilation shall be provided for the continuous removal of hazardous gases or vapors; and (3) vent openings or ducts shall lead to a safe location outside of buildings; and (4) vents ducts and openings shall be of sufficient area to relieve explosion pressures within the vault, and all portions of vent ducts within the buildings shall be of reinforced concrete construction.

28.2.1.2 Not Containing Liquid That Will Burn

Transformers and capacitors that do not contain a liquid that will burn shall be installed in vaults complying with item 28.2.1.1 or be approved for Class 1 locations.

28.3 Meters, Instruments and Relays

28.3.1 Class 1, Division 1

In Class 1, Division 1 locations meters, instruments, and relays, including kilowatt-hour meters, instrument transformers, resistors, rectifiers, and thermionic tubes, shall be provided with enclosures approved for Class 1, Division 1 locations.

28.3.2 Class 1, Division 2

In Class 1, Division 2 locations, meters, instruments, and relays shall comply with the provisions of items 28.3.2.1 through 28.3.2.6 below.

28.3.2.1 Contacts

Switches, circuit breakers, and make-and-break contacts of pushbuttons, relays, alarm bells, and horns shall have enclosures approved for Class 1, Division 1 locations.

Exception:

General purposes enclosures shall be permitted, if current-interrupting contacts are: (1) Immersed in oil; or, (2) enclosed within a chamber hermetically sealed against the entrance of gases or vapors; or (3) in circuits that under normal conditions do not release sufficient energy to ignite a specific hazardous atmosphere mixture, i.e., are non-incendiary.

28.3.2.2 Resistors and Similar Equipment

Resistors, resistance devices, thermionic tubes, rectifiers, and similar equipment that are used in or in connection with meters, instruments, and relays shall comply with item 28.3.1.

Exception:

General purpose-type enclosures shall be permitted if such equipment is without make-and-break or sliding contacts (other than as provided in item 28.3.2.1) and if the maximum operating temperature of any exposed surface will not exceed 80 percent of the autoignition temperature in degrees Celsius of the gas or vapor

involved or has been tested and found incapable of igniting the gas or vapor.

28.3.2.3 Without Make-and-Break Contacts

Transformer windings, impedance coils, solenoids, and other windings that do not incorporate sliding or make-and-break contacts shall be provided with enclosures that may be of the general purpose-type.

28.3.2.4 General Purpose Assemblies

Where an assembly is made of components for which general purpose enclosures are acceptable as provided in items 28.3.2.1 through 28.3.2.3, a single general purpose enclosure shall be acceptable for the assembly. Where such an assembly includes any of the equipment described in item 28.3.2.2, the maximum obtainable surface temperature of any component of the assembly shall be clearly and permanently indicated on the outside of the enclosure. Alternatively, approved equipment shall be permitted to be marked to indicate the temperature range for which it is suitable.

28.3.2.5 Fuses

Where general purpose enclosures are permitted in items 28.3.2.1 through 28.3.2.4, fuses for overcurrent protection of the instrument circuits shall be permitted to be mounted in general purpose enclosures if such fuses do not exceed a 3 ampere rating at 120 volts and if each such fuse is preceded by a switch complying with item 28.3.2.1.

28.3.2.6 Connections

To facilitate replacements, process control instruments shall be permitted to be connected through flexible cord, attachment plug, and receptacle, provided: (1) a switch complying with item 28.3.2.1 is provided so that the attachment plug is not depended on to interrupt current, and (2) the current does not exceed 3 amperes at 120 volts; and (3) the power supply cord length does not exceed 1 m, is of a type approved for extra-hard usage or for hard usage if protected by location, and is supplied through an attachment plug and receptacle of the locking and grounding type; and (4) only necessary receptacles are provided; and (5) the receptacle carries a label warning against unplugging under load.

28.4 Wiring Methods

Wiring methods shall comply with items 28.4.1 and 28.4.2 below.

28.4.1 Class 1, Division 1

In Class 1, Division 1 locations, threaded rigid metal conduit, threaded steel intermediate metal conduit or mineral-insulated metal-sheathed type cable with termination fittings approved for the location shall be the wiring method employed. All boxes, fittings and joints shall be threaded for connection to conduit or cable terminations, and shall be explosion-proof. Threaded joints shall be made with at least 5 threads fully engaged. Mineral-insulated metal-sheathed type cable shall be installed and supported in a manner to avoid tensile stress at the termination fittings. Where necessary to employ flexible connections, as at motor terminals, flexible fittings approved for Class 1, Division 1 locations shall be used.

28.4.2 Class 1, Division 2

In Class 1, Division 2 locations, threaded rigid metal conduit, threaded steel intermediate metal conduit, enclosed gasketed busways, or mineral-insulated metal-sheathed, metal clad, shielded non-metallic sheathed or tray cable with approved termination fittings shall be the wiring method employed. Mineral-insulated metal-sheathed, metal clad, shielded non-metallic sheathed or tray cable shall be installed in a manner to avoid tensile stress at the termination fittings. Boxes, fittings, and joints shall not be required to be explosion-proof except as required by items 28.3.2.1, 28.6.2.1 and 28.14.2.1. Where provisions must be made for limited flexibility, as at motor terminals, flexible metal fittings, flexible metal conduit with approved fittings, liquid-tight flexible metal conduit with approved fittings, or flexible cord approved for extra-hard usage and provided with approved bushed fittings shall be used. An additional conductor for grounding shall be included in the flexible cord unless other acceptable means of grounding are provided.

Exception:

Wiring, which under normal conditions cannot release sufficient energy to ignite a specific hazardous atmospheric mixture by opening, shorting or grounding, shall be permitted using any of the methods suitable for wiring in ordinary locations.

28.5 Sealing and Drainage

Seals in conduit and cable systems shall comply with items 28.5.1 through 28.5.6 below. Sealing compound shall be of a type approved for the conditions and use. Sealing compound shall be used in mineral-insulated metal sheathed cable termination fittings to exclude moisture and other fluids from the cable insulation.

Seals are provided in conduit and cable systems to prevent the passage of gases, vapors, or flames from one portion of the electrical installation to another through the conduit. Such communication through mineral-insulated metal sheathed cable is inherently prevented by construction of the cable.

28.5.1 Conduit Seals Class 1, Division 1

In Class 1, Division 1 locations, conduit seals shall be located as indicated in items 28.5.1.1 through 28.5.1.4 below.

- 28.5.1.1 In each conduit run entering an enclosure for switches, circuit breakers, fuses, relays, resistors, or other apparatus that may produce arcs, sparks, or high temperatures. Seals shall be placed as close as practicable and in no case more than 45 cm from such enclosures. Explosion-proof unions, couplings, elbows, capped elbows and conduit bodies shall be the only enclosures or fittings permitted between the sealing fitting and the enclosure. The conduit bodies shall not be larger than the largest trade size of the conduits.
- 28.5.1.2 In each conduit run of 48 mm size or larger entering an enclosure or fitting housing terminals, splices or taps and within 45 cm of such enclosure or fitting. (See notes under Group B in Table 4).
- 28.5.1.3 Where two or more enclosures for which seals are required under items 28.5.1.1 and 28.5.1.2 are connected by nipples or by runs of conduit not more than 90 cm long, a single seal in each such nipple connection or run of conduit shall be

considered sufficient if located not more than 45 cm from either enclosure.

- 28.5.1.4 In each conduit run leaving the Class 1, Division 1 hazardous area: The sealing fitting shall be permitted on either side of the boundary of such hazardous location, but shall be so designed and installed that any gases or vapors that may enter the conduit system within the Division 1 hazardous location will not enter or be communicated to the conduit beyond the seal. There shall be no union, coupling, box, or fitting in the conduit between the sealing fitting and the point at which the conduit leaves the Division 1 hazardous location.

Exception:

Metal conduit containing no unions, couplings, boxes or fittings that passes completely through a Class 1, Division 1 location with no fittings less than 30 cm beyond each boundary shall not be required to be sealed if the termination points of the unbroken conduit are in nonhazardous locations.

28.5.2 **Conduit Seals Class 1, Division 2**

In Class 1, Division 2 locations, conduit seals shall be located as follows:

- 28.5.2.1 For connections to explosion-proof enclosures that are required to be approved for Class 1 locations, seals shall be provided in accordance with items 28.5.1.1 through 28.5.1.3. All portions of the conduit run or nipple between the seal and such enclosure shall comply with item 28.4.1.
- 28.5.2.2 In each conduit run passing from a Class 1, Division 2 location into a nonhazardous location. The sealing fitting shall be permitted on either side of the boundary of such location, but shall be so designed and installed that any gases or vapors that may enter the conduit system within the Division 2 location will not enter or be communicated to the conduit beyond the seal. Rigid metal conduit or threaded steel intermediate metal conduit shall be used between the sealing fitting and the point at which the conduit leaves the hazardous location, and a threaded connection shall be used at the sealing fitting. There shall be no union, coupling, box or fitting in the conduit between the sealing fitting and the point at which the conduit leaves the hazardous location.

Exception:

Metal conduit containing no unions, couplings, boxes or fittings, that passes completely through a Class 1, Division 2 location with no fittings less than 30 cm beyond each boundary shall not be required to be sealed if the termination points of the unbroken conduit are in nonhazardous locations.

28.5.3 **Class 1, Divisions 1 and 2**

Where required, seals in Class 1, Division 1 and 2 locations shall comply with the provisions of items 28.5.3.1 through 28.5.3.5 below:

28.5.3.1 **Fittings**

Enclosures for connections or equipment shall be provided with an approved integral means for sealing, or sealing fittings approved for Class 1 locations shall be used. Sealing fittings shall be accessible.

28.5.3.2 **Compound**

Sealing compound shall be approved for the purpose, shall not be affected by the

surrounding atmosphere or liquids, and shall not have a melting point of less than 93°C.

28.5.3.3 Thickness of Compounds

In a completed seal, the minimum thickness of the sealing compound shall not be less than the trade size of the conduit, and in no case, less than 15 mm.

28.5.3.4 Splices and Taps

Splices and taps shall not be made in fittings intended only for sealing with compound, nor shall other fittings in which splices or taps are made be filled with compound.

28.5.3.5 Assemblies

In an assembly where equipment that may produce arcs, sparks, or high temperatures is located in a compartment separate from the compartment containing splices or taps, and an integral seal is provided where conductors pass from one compartment to the other, the entire assembly shall be approved for Class 1 locations. Seals in conduit connections to the compartment containing splices or taps shall be provided in Class 1, Division 1 locations where required by item 28.5.1.2.

28.5.4 Cable Seals, Class 1, Division 1

In Class 1, Division 1 locations, each multiconductor cable in conduit shall be considered as a single conductor if the cable is incapable of transmitting gases or vapors through the cable core. These cables shall be sealed in accordance with item 28.5.1.

Cables with gas/vapor-tight continuous sheath capable of transmitting gases or vapors through the cable core shall be sealed in the hazardous location after removing the jacket and any other coverings so that the sealing compound will surround each individual insulated conductor and the outer jacket.

28.5.5 Cable Seals, Class 1, Division 2

In Class 1, Division 2 locations, cable seals shall be located as indicated in items 28.5.5.1 through 28.5.5.4 below:

28.5.5.1 Cables entering enclosures which are required to be approved for Class 1 locations shall be sealed at the point of entrance. The sealing fitting shall comply with item 28.5.2.1. Multiconductor cables shall be sealed after removing the jacket and any other coverings so that the sealing compound will surround each individual insulated conductor and the outer jacket.

28.5.5.2 Cables with gas/vapor-tight continuous sheath and which will not transmit gases or vapors through the cable core in excess of the quantity permitted for seal fittings shall not be required to be sealed except as required in item 28.5.5.1. The minimum length of such cable run shall not be less than that length which limits gas or vapor flow to the rate permitted for seal fittings.

28.5.5.3 Cables with a gas/vapor-tight continuous sheath and capable of transmitting gases or vapors through the cable core shall be sealed in the hazardous location in such a manner as to prevent passage of gases or vapors into a nonhazardous location.

Exception:

Cables with an unbroken gas/vapor-tight continuous sheath shall be permitted to pass through a Class 1, Division 2 location without seals.

- 28.5.5.4 Cables which do not have gas/vapor-tight continuous sheath shall be sealed at the boundary of the hazardous and nonhazardous location in such a manner as to prevent passage of gases or vapors into a nonhazardous location.

28.5.6 **Drainage**

28.5.6.1 **Control Equipment**

Where there is a probability that liquid or other condensed vapor may be trapped within enclosures for control equipment or at any point in the raceway system, approved means shall be provided to prevent accumulation or to permit periodic draining of such liquid or condensed vapor.

28.5.6.2 **Motors and Generators**

Where the authority having jurisdiction judges that there is a probability that liquid or condensed vapor may accumulate within motors or generators, joints and conduit systems shall be arranged to minimize entrance of liquid. If means to prevent accumulation or to permit periodic draining are judged necessary, such means shall be provided at the time of manufacture and shall be considered an integral part of the machine.

28.5.6.3 **Canned Pumps, Etc.**

For canned pumps, process connections for flow, pressure, or analysis measurement, that depend upon a single seal diaphragm or tube to prevent process fluids from entering the electrical conduit system, and additional approved seal or barrier shall be provided with an adequate drain between the seals in such a manner that leaks would be obvious.

28.6 **Switches, Circuit Breakers, Motor Controllers and Fuses**

28.6.1 **Class 1, Division 1**

In Class 1, Division 1 locations, switches, circuit breakers, motor controllers, and fuses, including pushbuttons, relays and similar devices shall be provided with enclosures; and the enclosure in each case, together with the enclosed apparatus, shall be approved as a complete assembly for use in Class 1, Division 1 locations.

28.6.2 **Class 1, Division 2**

Switches, circuit breakers, motor controllers, and fuses in Class 1, Division 2 locations shall comply with the provisions in items 28.6.2.1 through 28.6.2.4 below:

28.6.2.1 **Type Required**

Circuit breakers, motor controllers, and switches intended to interrupt current in the normal performance of the function for which they are installed shall be provided with enclosures approved for Class 1, Division 1 locations, unless general purpose enclosures are provided and (1) the interruption of current occurs within a chamber hermetically sealed against the entrance of gases and vapors, or (2) the current make-and-break contacts are oil-immersed and of the general

purpose-type having a 50 mm minimum immersion for power and a 25 mm minimum immersion for control.

28.6.2.2 **Isolating Switches**

General purpose-type enclosures containing no fuses shall be permitted to enclose disconnecting and isolating switches that are not intended to interrupt current.

28.6.2.3 **Fuses**

For the protection of motors, appliances, and lamps, other than as provided in item 28.6.2.4, standard plug or cartridge fuses shall be permitted, provided they are placed within enclosures approved for the purpose and for the location; or fuses shall be permitted if they are within general purpose enclosures, if they are approved for the purpose; and if they are of a type in which the operating element is immersed in oil or other approved liquid or the operating element is enclosed within a chamber hermetically sealed against the entrance of gases and vapors.

28.6.2.4 **Fuses or Circuit Breakers for Overcurrent Protection**

Where not more than 10 sets of approved enclosed fuses or not more than 10 circuit breakers that are not intended to be used as switches for the interruption of current are installed for branch circuit or feeder protection in any one room, area, or section of the Class 1, Division 2 location, general purpose type enclosures for such fuses or circuit breakers shall be permitted if the fuses or circuit breakers are for the protection of circuits or feeders supplying lamps in fixed positions only.

A set of fuses is all the fuses required to protect all the ungrounded conductors of a circuit. For example, a group of 3 fuses protecting an ungrounded 3-phase circuit, and a single fuse protecting the ungrounded conductor of an identified 2-wire single-phase circuit, is a set of fuses in each instance.

Fuses complying with item 28.6.2.3 shall not be required to be included in counting the ten sets of fuses permitted in general purpose enclosures.

28.7 **Control Transformers and Resistors**

Transformers, impedance coils, and resistors used as, or in conjunction with, control equipment for motors, generators, and appliances shall comply with items 28.7.1 and 28.7.2 below.

28.7.1 **Class 1, Division 1**

In Class 1, Division 1 locations, transformers, impedance coils, and resistors, together with any switching mechanism associated with them, shall be provided with enclosures approved for Class 1, Division 1 locations.

28.7.2 **Class 1, Division 2**

In Class 1, Division 2 locations, control transformers and resistors shall comply with the provisions of items 28.7.2.1 through 28.7.2.3 below:

28.7.2.1 **Switching Mechanisms**

Switching mechanisms used in conjunction with transformers, impedance coils, and resistors shall comply with item 28.6.2.

28.7.2.2 **Coils and Windings**

Enclosures for windings of transformers, solenoids, or impedance coils shall be

permitted to be of the general purpose-type.

28.7.2.3 **Resistors**

Resistors shall be provided with enclosures; and the assembly shall be approved for Class 1 locations, unless resistance is nonvariable and maximum operating temperature, in degrees Celsius, will not exceed 80 percent of the ignition temperature of the gas or vapors involved, or has been tested and found incapable of igniting the gas or vapor.

28.8 **Motors and Generators**

28.8.1 **Class 1, Division 1**

In Class 1, Division 1 locations, motors, generators and other rotating electric machinery shall be: (1) approved for Class 1, Division 1 locations; or (2) of the totally enclosed type supplied with positive-pressure ventilation from a source of clean air with discharge to a safe area, so arranged to prevent energizing of the machine until ventilation has been established and the enclosure has been purged with a least 10 volumes of air, and also arranged to automatically de-energize the equipment when the air supply fails; or (3) of the totally enclosed inert-gas-filled type supplied with a suitable reliable source of inert gas for pressurizing the enclosure, with devices provided to insure a positive pressure in the enclosure, and arranged to automatically de-energize the equipment when the gas supply fails; or (4) of a type designed to be submerged in a liquid which is flammable only when vaporized and mixed with air, or in a gas or vapor at a pressure greater than atmospheric and which is flammable only when mixed with air; and the machine is so arranged to prevent energizing it until it has been purged with the liquid or gas to exclude air, and also arranged to automatically de-energize the equipment when the supply of liquid, or gas or vapor, fails or the pressure is reduced to atmospheric.

Totally enclosed motors shall have no external surface with an operating temperature in degrees Celsius in excess of 80 percent of the ignition temperature of the gas or vapor involved. Appropriate devices shall be provided to detect and automatically de-energize the motor or provide an adequate alarm if there is any increase in temperature of the motor beyond designed limits. Auxiliary equipment shall be of a type approved for location in which it is installed.

28.8.2 **Class 1, Division 2**

In Class 1, Division 2 locations, motors, generators, and other rotating electric machinery in which are employed sliding contacts, centrifugal or other types of switching mechanism (including motor overcurrent devices), or integral resistance devices, either while starting or while running, shall be approved for Class 1, Division 1 locations, unless such sliding contacts, switching mechanisms, and resistance devices are provided with enclosures approved for Class 1, Division 1 locations.

In Class 1, Division 2 locations, the installation of open or nonexplosion-proof enclosed motors, such as squirrel-cage induction motors without brushes, switching mechanisms, or similar arc-producing devices shall be permitted.

28.9 Lighting Fixtures

Lighting fixtures shall comply with items 28.9.1 or 28.9.2 below.

28.9.1 Class 1, Division 1

In Class 1, Division 1 locations, lighting fixtures shall comply with the provisions of items 28.9.1.1 through 28.9.1.4:

28.9.1.1 Approved Fixtures

Each fixture shall be approved as a complete assembly for the Class 1, Division 1 location and shall be clearly marked to indicate the maximum wattage of lamps for which it is approved. Fixtures intended for portable use shall be specifically approved as a complete assembly for that use.

28.9.1.2 Physical Damage

Each fixture shall be protected against physical damage by a suitable guard or by location.

28.9.1.3 Pendant Fixtures

Pendant fixtures shall be suspended by and supplied through threaded rigid metal conduit stems or threaded steel intermediate metal conduit stems, and threaded joints shall be provided with set screws or other effective means to prevent loosening. For stems longer than 30 cm, permanent and effective bracing against lateral displacement shall be provided at a level not more than 30 cm above the lower end of the stem, or flexibility in the form of a fitting or flexible connector approved for the purpose and for the Class 1, Division 1 location shall be provided not more than 30 cm from the point of attachment to the supporting box or fitting.

28.9.1.4 Supports

Boxes, box assemblies, or fittings used for the support of lighting fixtures shall be approved for the purpose and for Class 1 locations.

28.9.2 Class 1, Division 2

In Class 1, Division 2 locations, lighting fixtures shall comply with the provisions of items 28.9.2.1 through 28.9.2.6:

28.9.2.1 Portable Lamps

Portable lamps shall comply with item 28.9.1.1.

28.9.2.2 Fixed Lighting

Lighting fixtures for fixed lighting shall be protected from physical damage by suitable guards or by location. Where there is danger that falling sparks or hot metal from lamps or fixtures might ignite localized concentrations of flammable vapors or gases, suitable enclosures or other effective protective means shall be provided. Where lamps are of a size or type that may, under normal operating conditions, reach surface temperatures exceeding 80 percent of the ignition temperature of the gas or vapor involved, fixtures shall comply with item 28.9.1.1 or shall be of a type which has been tested and found incapable of igniting the gas or vapor if the ignition temperature is not exceeded.

28.9.2.3 Pendant Fixtures

Pendant fixtures shall be suspended by threaded rigid metal conduit stems, threaded steel intermediate metal conduit stems, or by other approved means. For rigid stems longer than 30 cm, permanent and effective bracing against lateral displacement shall be provided at a level not more than 30 cm above the lower end of the stem, or flexibility in the form of a fitting or flexible connector approved for the purpose shall be provided not more than 30 cm from the point of attachment to the supporting box or fitting.

28.9.2.4 Supports

Boxes, box assemblies, or fittings used for the support of lighting fixtures shall be approved for the purpose.

28.9.2.5 Switches

Switches that are a part of an assembled fixture or of an individual lampholder shall comply with item 28.6.2.1.

28.9.2.6 Starting Equipment

Starting and control equipment for electric discharge lamps shall comply with item 28.7.2.

Exception:

A thermal protector potted into a thermally protected fluorescent lamp ballast if the lighting fixture is approved for locations of this Class and Division.

28.10 Utilization Equipment**28.10.1 Class 1, Division 1**

In Class 1, Division 1 locations, all utilization equipment shall be approved for Class 1, Division 1 locations.

28.10.2 Class 1, Division 2

In Class 1, Division 2 locations, all utilization equipment shall comply with the provisions of items 28.10.2.1 through 28.10.2.3 below:

28.10.2.1 Heaters

Electrically heated utilization equipment shall conform with either items 28.10.2.1.1 or 28.10.2.1.2 below:

- 28.10.2.1.1 The heater shall not exceed 80 percent of the ignition temperature in degrees Celsius of the gas or vapor involved on any surface likely to be exposed to the gas or vapor when continuously energized at the maximum rated ambient temperature. If a temperature controller is not provided, these conditions shall apply when the heater is operated at 120 percent of rated voltage.

- 28.10.2.1.2 The heater shall be approved for Class 1, Division 1 locations.

28.10.2.2 Motors

Motors of motor-driven utilization equipment shall comply with item 28.8.2.

28.10.2.3 Switches, Circuit Breakers, and Fuses

Switches, circuit breakers, and fuses shall comply with item 29.6.2.

28.11 Flexible Cords, Class 1, Divisions 1 and 2

A flexible cord shall be permitted only for connection between a portable lamp or other portable utilization equipment and the fixed portion of its supply circuit; and where used shall: (1) be of a type approved for extra hard usage; and (2) contain, in addition to the conductors of the circuit, a grounding conductor; and (3) be connected to terminals or to supply conductors in an approved manner; and (4) be supported by clamps or by other suitable means in such a manner that there will be no tension on the terminal connections; and (5) be provided with suitable seals where the flexible cord enters boxes, fittings, or enclosures of the explosion-proof type.

Exception:

As provided in items 28.3.2.6 and 28.4.2.

28.12 Receptacles and Attachment Plugs, Class 1, Divisions 1 and 2

Receptacles and attachment plugs shall be of the type providing for connection to the grounding conductor of a flexible cord and shall be approved for Class 1 locations.

Exception:

As provided in item 28.3.2.6.

28.13 Conductor Insulation Class 1, Divisions 1 and 2

Where condensed vapors or liquids may collect on or come in contact with the insulation on conductors, such insulation shall be of a type approved for use under such conditions; or the insulation shall be protected by a sheath of lead or by other approved means.

28.14 Signaling, Alarm, Remote-Control, and Communication Systems**28.14.1 Class 1, Division 1**

In Class 1, Division 1 locations, all apparatus and equipment of signalling, alarm, remote-control, and communication systems, regardless of voltage, shall be approved for Class 1, Division 1 locations, and all wiring shall comply with items 28.4.1 and 28.5.1.3.

28.14.2 Class 1, Division 2

In Class 1, Division 2 locations, signaling, alarm, remote-control, and communication systems shall comply with the provisions of items 28.14.2.1 through 28.14.2.4 below:

28.14.2.1 Contacts

Switches, circuit breakers, and make-and-break contacts of pushbuttons, relays, alarm bells, and horns shall have enclosures approved for Class 1, Division 1 locations.

Exception:

General purpose enclosures shall be permitted if current interrupting contacts are:

(1) immersed in oil; or (2) enclosed within a chamber hermetically sealed against the entrance of gases or vapors; or (3) in circuits that under normal conditions do not release sufficient energy to ignite a specific hazardous atmospheric mixture, that is they are non-incendiary.

28.14.2.2 Resistors and Similar Equipment

Resistors, resistance devices, thermionic tubes, rectifiers, and similar equipment shall comply with item 28.3.2.2.

28.14.2.3 Protectors

Enclosures shall be provided for lightning protective devices and for fuses. Such enclosures shall be permitted to be of the general purpose-type.

28.14.2.4 Wiring and Sealing

All wiring shall comply with items 28.4.2 and 28.5.2 and 28.5.3.

28.15 Live Parts, Class 1, Divisions 1 and 2

There shall be no exposed live parts.

28.16 Grounding, Class 1, Divisions 1 and 2

Wiring and equipment shall be grounded as specified in items 28.16.1 through 28.16.6 below:

28.16.1 Exposed Parts

The exposed noncurrent-carrying metal parts of equipment, such as the frames or metal exteriors of motors, fixed or portable lamps, lighting fixtures, or other utilization equipment, and cabinets, cases, and conduit, shall be grounded as specified in item 9.

28.16.2 Bonding

The locknut-bushing and double-locknut types of contacts shall not be depended upon for bonding purposes, but bonding jumpers with proper fittings or other approved means shall be used. Such means of bonding shall apply to all intervening raceways, fittings, boxes, enclosures, etc., between hazardous areas and the point of grounding for service equipment. Where flexible conduit is used as permitted in item 28.4.2, bonding jumpers with proper fittings shall be provided around such conduit.

28.16.3 Lightning Protection

Each ungrounded service conductor of a wiring system in a Class 1 location, where supplied from an overhead line in an area where lightning disturbances are prevalent, shall be protected by a lightning protective device of proper type. Lightning protective devices shall be connected to the service conductors on the supply side of the service disconnecting means, and shall be bonded to the raceway system at the service entrance.

28.16.4 Grounded Service Conductor Bonded to Raceway

Wiring in a Class 1 location, where supplied from a grounded alternating-current supply system in which a grounded conductor is a part of the service, shall have the grounded service conductor bonded to the raceway system and to the grounding conductor for the raceway system. The bonding connection to the

grounded service conductor shall be made on the supply side of the service disconnecting means.

28.16.5 Transformer Ground Bonded to Raceway

Wiring in a Class 1 location, where supplied from a grounded alternating-current supply system in which no grounded conductor is a part of the service, shall be provided with a metal connection between the supply system ground and the service equipment enclosure.

28.16.6 Multiple Grounds

Where it is necessary to abandon one or more grounding connections to avoid objectionable passage of current over the grounding conductors, the connection required in items 28.16.4 and 28.16.5 shall not be abandoned while any other grounding connection remains connected to the supply.

29. CLASS 2 LOCATIONS

29.1 General

The general rules of Section 7.0 shall apply to the electric wiring and equipment in locations classified as Class 2 locations in item 27.4, except as modified by this item 29.

"Dust-ignition-proof," as used in this item shall mean enclosed in a manner that will exclude ignitable amounts of dusts or amounts that might affect performance or rating and that, where installed and protected in accordance with Section 7.0, will not permit arcs, sparks, or heat otherwise generated or liberated inside of the enclosure to cause ignition of exterior accumulations or atmospheric suspensions of a specified dust on or in the vicinity of the enclosure.

Equipment installed in Class 2 locations shall be able to function at full rating without developing surface temperatures high enough to cause excessive dehydration or gradual carbonization of any organic dust deposits that may occur.

Dust that is carbonized or excessively dry is highly susceptible to spontaneous ignition.

In general, the maximum surface temperatures under actual operating conditions shall not exceed 165°C for equipment that is not subject to overloading and 120°C for equipment (such as motors or power transformers) that may be overloaded.

Equipment and wiring of the type defined in item 7.1.1 as explosion-proof shall not be required and shall not be acceptable in Class 2 locations unless approved for such locations.

29.2 Transformers and Capacitors

29.2.1 Class 2, Division 1

In Class 2, Division 1 locations, transformers and capacitors shall comply with the provisions of items 29.2.1.1 through 29.2.1.3 below:

29.2.1.1 Containing Liquid That Will Burn

Transformers and capacitors containing a liquid that will burn shall be installed

only in approved vaults and in addition: (1) doors or other openings communicating with the hazardous location shall have self-closing fire doors on both sides of the wall, and the doors shall be carefully fitted and provided with suitable seals (such as weather stripping) to minimize the entrance of dust into the vault; and (2) vent openings and ducts shall communicate only with the outside air; and (3) suitable pressure-relief openings communicating with the outside air shall be provided.

29.2.1.2 Not Containing Liquid That Will Burn

Transformers and capacitors that do not contain a liquid that will burn shall be installed in vaults, or be approved as a complete assembly, including terminal connections for Class 2 locations.

29.2.1.3 Metal Dusts

No transformer or capacitor shall be installed in a location where dust from magnesium, aluminum, aluminum bronze powders, or other metals of similarly hazardous characteristics may be present.

29.2.2 Class 2, Division 2

In Class 2, Division 2 locations, transformers and capacitors shall comply with the provisions of items 29.2.2.1 through 29.2.2.3 below:

29.2.2.1 Containing Liquid That Will Burn

Transformers and capacitors containing a liquid that will burn shall be installed in vaults.

29.2.2.2 Containing Askarel

Transformers containing askarel and rated in excess of 25 kva shall: (1) be provided with pressure-relief vents; and (2) be provided with a means for absorbing any gases generated by arcing inside the case, or the pressure-relief vents shall be connected to a chimney or flue that will carry such gases outside the building; and (3) have an air space of not less than 15 cm between the transformer cases and any adjacent combustible material.

29.2.2.3 Dry-Type Transformers

Dry-type transformers shall be installed in vaults or shall have their windings and terminal connections enclosed in tight metal housings without ventilating or other openings; and operate at not over 600 volts.

29.3 Surge Protection, Class 2, Divisions 1 and 2

In geographical locations where lightning disturbances are prevalent and where supplied from overhead lines, wiring systems in Class 2 locations shall be suitably protected against high-voltage surges. This protection shall include suitable lightning protective devices, interconnection of all grounds, and surge-protective capacitors.

Interconnection of all grounds shall include grounds for primary and secondary lightning protective devices, secondary system grounds, if any, and grounds of conduit and equipment of the premises wiring system.

For ungrounded secondary systems, secondary lightning protective devices may

be provided both at the service and at the point where the secondary system receives its supply. The intervening secondary conductors shall be permitted as the metallic connection between the secondary protective devices, if grounds for the primary and secondary devices are metallically interconnected at the supply end of the secondary system, and if the secondary devices are grounded to the raceway system at the load end of the secondary system.

Surge-protective capacitors shall be of a type designed for the specific duty, shall be connected to each ungrounded service conductor, and shall be grounded to the interior conduit system. Capacitors shall be protected by 30 ampere fuses of suitable type and voltage rating, or by automatic circuit breakers of suitable type and rating, and shall be connected to the supply conductors on the supply side of the service disconnecting means.

29.4 **Wiring Methods**

Wiring methods shall comply with items 29.4.1 and 29.4.2 below:

29.4.1 **Class 2, Division 1**

In Class 2, Division 1 locations, threaded rigid metal conduit, threaded steel intermediate metal conduit or mineral-insulated metal sheathed cable with termination fittings approved for the location shall be the wiring method employed. Mineral-insulated metal-sheathed cable shall be installed and supported in a manner to avoid tensile stress at the termination fittings.

29.4.1.1 **Fittings and Boxes**

Fittings and boxes shall be provided with threaded bosses (bulges beyond the surrounding or adjacent surface) for connection to conduit or cable terminations, shall have close fitting covers, and shall have no openings (such as holes for attachment screws) through which dust might enter or through which sparks or burning material might escape. Fittings and boxes in which taps, joints, or terminal connections are made, or that are used in locations where dusts are of a combustible electrically conductive nature, shall be approved for Class 2 locations.

29.4.1.2 **Flexible Connections**

Where necessary to employ flexible connections, dust-tight connectors, liquid-tight flexible metal conduit with approved fittings, or flexible cord approved for extra hard usage and provided with bushed fittings shall be used, except that where dusts are of an electrically conducting nature flexible cords shall be provided with dust-tight seals at both ends. An additional conductor for grounding shall be provided in the flexible cord unless other acceptable means of grounding is provided. Where flexible connections are subject to oil or other corrosive conditions, the insulation of the conductors shall be of a type approved for the condition or shall be protected by means of a suitable sheath.

29.4.2 **Class 2, Division 2**

In Class 2, Division 2 locations, rigid metal conduit, intermediate metal conduit, electrical metallic tubing, dust-tight wireways, or mineral-insulated metal-sheathed, metal-clad, or shielded non-metallic sheathed cable with approved termination fittings shall be the wiring method employed.

29.4.2.1 Wireways, Fittings, and Boxes

Wireways, fittings, and boxes in which taps, joints, or terminal connections are made shall be designed to minimize the entrance of dust, and: (1) shall be provided with telescoping or close fitting covers or other effective means to prevent the escape of sparks or burning material, and (2) shall have no openings (such as holes for attachment screws) through which, after installation, sparks or burning material might escape or through which adjacent combustible material might be ignited.

29.4.2.2 Flexible Connections

Where flexible connections are necessary, item 29.4.1.2 shall apply.

29.5 Sealing, Class 2, Divisions 1 and 2

Where a raceway provides communication between an enclosure that is required to be dust-ignition-proof and one that is not, suitable means shall be provided to prevent the entrance of dust into the dust-ignition-proof enclosure through the raceway. One of the following means shall be permitted:

A permanent and effective seal.

A horizontal raceway not less than 3 m long.

A vertical raceway not less than 1.5 m long and extending downward from the dust-ignition-proof enclosure. Sealing fittings shall be accessible.

29.6 Switches, Circuit Breakers, Motor Controllers, and Fuses**29.6.1 Class 2, Division 1**

In Class 2, Division 1 locations, switches, circuit breakers, motor controllers, and fuses shall comply with the following:

29.6.1.1 Type Required

Switches, circuit breakers, motor controllers, and fuses, including pushbuttons, relays, and similar devices that are intended to interrupt current during normal operation or that are installed where dusts of a combustible electrically conductive nature may be present shall be provided with dust-ignition-proof enclosures, which, together with the enclosed equipment in each case, shall be approved as a complete assembly for Class 2 locations.

29.6.1.2 Isolating Switches

Disconnecting and isolating switches containing no fuses and not intended to interrupt current and not installed where dusts may be of an electrically conductive nature shall be provided with tight metal enclosures that shall be designed to minimize the entrance of dust, and that shall: (1) be equipped with telescoping or close fitting covers or with other effective means to prevent the escape of sparks or burning material, and (2) have no openings (such as holes for attachment screws) through which, after installation, sparks, or burning material might escape or through which exterior accumulations of dust or adjacent combustible material might be ignited.

29.6.1.3 Metal Dusts

In locations where dust from magnesium, aluminum, aluminum bronze powders,

or other metals of similarly hazardous characteristics may be present, fuses, switches, motor controllers, and circuit breakers shall have enclosures specifically approved for such locations.

29.6.2 Class 2, Division 2

In Class 2, Division 2 locations, enclosures for fuses, switches, circuit breakers, and motor controllers, including pushbuttons, relays, and similar devices, shall comply with item 29.6.1.2.

29.7 Control Transformers and Resistors

29.7.1 Class 2, Division 1

In Class 2, Division 1 locations, control transformers, solenoids, impedance coils, resistors, and any overcurrent devices or switching mechanisms associated with them shall have dust-ignition-proof enclosures approved for Class 2 locations. No control transformer, impedance coil, or resistor shall be installed in a location where dust from magnesium, aluminum, aluminum bronze powders, or other metals of similarly hazardous characteristics may be present unless provided with an enclosure approved for the specific location.

29.7.2 Class 2, Division 2

In Class 2, Division 2 locations, transformers and resistors shall comply with the provisions of items 29.7.2.1 through 29.7.2.3 below:

29.7.2.1 Switching Mechanisms

Switching mechanisms (including overcurrent devices) associated with control transformers, solenoids, impedance coils, and resistors shall be provided with enclosures complying with item 29.6.1.2.

29.7.2.2 Coils and Windings

Where not located in the same enclosure with switching mechanisms, control transformers, solenoids, and impedance coils shall be provided with tight metal housings without ventilating openings.

29.7.2.3 Resistors

Resistors and resistance devices shall have dust-ignition-proof enclosures approved for Class 2 locations.

Exception:

Where the maximum normal operating temperature of the resistor will not exceed 120°C, nonadjustable resistors or resistors that are part of an automatically timed starting sequence shall be permitted to have enclosures complying with item 29.7.2.2.

29.8 Motors and Generators

29.8.1 Class 2, Division 1

In Class 2, Division 1 locations, motors, generators, and other rotating electric machinery shall be: (1) approved for Class 2, Division 1 locations, or (2) totally enclosed pipe ventilated, meeting temperature limitations in item 29.1.

29.8.2 Class 2, Division 2

In Class 2, Division 2 locations, motors, generators, and other rotating electric machinery shall be dust-ignition-proof or totally enclosed pipe-ventilated, for which maximum surface temperatures shall not exceed 120°C.

Exception:

If the authority having jurisdiction believes accumulations of nonconductive nonabrasive dust will be moderate; and if machines can be easily reached for routine cleaning and maintenance, the following may be installed:

- (1) Standard open-type machines without sliding contacts, centrifugal or other types of switching mechanism (including motor overcurrent devices), or integral resistance devices.
- (2) Standard open-type machines with such contacts, switching mechanisms, or resistance devices enclosed within tight metal housings without ventilating or other openings.
- (3) Self-cleaning textile motors of the squirrel-cage type.

29.9 Ventilating Piping

Ventilating pipes for motors, generators, or other rotating electric machinery, or for enclosures for electric equipment shall comply with the following: (1) lead directly to a source of clean air outside of buildings; (2) be screened at the outer ends to prevent the entrance of small animals or birds; and (3) be protected against physical damage and against rusting or other corrosive influences.

Ventilating pipes shall also comply with items 29.9.1 and 29.9.2 below.

29.9.1 Class 2, Division 1

In Class 2, Division 1 locations, ventilating pipes, including their connections to motors or to the dust-ignition-proof enclosures for other equipment, shall be suit-tight throughout their length. For metal pipes, seams and joints shall comply with one of the following: (1) be riveted and soldered; (2) be bolted and soldered; (3) be welded, or (4) be rendered dust-tight by some other equally effective means.

29.9.2 Class 2, Division 2

In Class 2, Division 2 locations, ventilating pipes and their connections shall be sufficiently tight to prevent the entrance of appreciable quantities of dust into the ventilated equipment or enclosure, and to prevent the escape of sparks, flames, or burning material that might ignite dust accumulations or combustible material in the vicinity. For metal pipes, lock seams and riveted or welded joints shall be permitted; and tight-fitting slip joints shall be permitted where some flexibility is necessary, as at connections to motors.

29.10 Utilization Equipment**29.10.1 Class 2, Division 1**

In Class 2, Division 1 locations, all utilization equipment shall be approved for Class 2 locations. Where dust from magnesium, aluminum, aluminum bronze powders, or other metals of similarly hazardous characteristics may be present, such equipment shall be approved for the specific location.

29.10.2 Class 2, Division 2

In Class 2, Division 2 locations, all utilization equipment shall comply with the provisions of items 29.10.2.1 through 29.10.2.4 below:

29.10.2.1 Heaters

Electrically heated utilization equipment shall be approved for Class 2 locations.

29.10.2.2 Motors

Motors of motor-driven utilization equipment shall comply with item 29.8.2.

29.10.2.3 Switches, Circuit Breakers, and Fuses

Enclosures for switches, circuit breakers, and fuses shall comply with item 29.6.1.2.

29.10.2.4 Transformers, Impedance Coils, and Resistors

Transformers, solenoids, impedance coils, and resistors shall comply with item 29.7.2.

29.11 Lighting Fixtures

Lighting fixtures shall comply with items 29.11.1 and 29.11.2 below:

29.11.1 Class 2, Division 1

In Class 2, Division 1 locations, lighting fixtures for fixed and portable lighting shall comply with the provisions of items 29.11.1.1 through 29.11.1.4 below:

29.11.1.1 Approved Fixtures

Each fixture shall be approved for Class 2 locations and shall be clearly marked to indicate the maximum wattage of the lamp for which it is approved. In locations where dust from magnesium, aluminium, aluminum bronze powders, or other metals of similarly hazardous characteristics may be present, fixtures for fixed or portable lighting and all auxiliary equipment shall be approved for the specific location.

29.11.1.2 Physical Damage

Each fixture shall be protected against physical damage by a suitable guard or by location.

29.11.1.3 Pendant Fixtures

Pendant fixtures shall be suspended by threaded rigid metal conduit stems, threaded steel intermediate metal conduit stems, by chains with approved fittings, or by other approved means. For rigid stems longer than 30 cm, permanent and effective bracing against lateral displacement shall be provided at a level not more than 30 cm above the lower end of the stem, or flexibility in the form of a fitting or a flexible connector approved for the purpose and for the location shall be provided not more than 30 cm from the point of attachment to the supporting box or fitting. Threaded joints shall be provided with set-screws or other effective means to prevent loosening. Where wiring between an outlet box or fitting and a pendant fixture is not enclosed in conduit, flexible cord approved for hard usage shall be used, and suitable seals shall be provided where the cord enters the fixture and the outlet box or fitting. Flexible cord shall not serve as the supporting means

for a fixture.

29.11.1.4 **Supports**

Boxes, box assemblies, or fittings used for the support of lighting fixtures shall be approved for the purpose and for Class 2 locations.

29.11.2 **Class 2, Division 2**

In Class 2, Division 2 locations, lighting fixtures shall comply with the provisions of items 29.11.2.1 through 29.11.2.6 below:

29.11.2.1 **Portable Lamps**

Portable lamps shall be approved for Class 2 locations. They shall be clearly marked to indicate the maximum wattage of lamps for which they are approved.

29.11.2.2 **Fixed Lighting**

Lighting fixtures for fixed lighting, where not of a type approved for Class 2 locations, shall provide enclosures for lamps and lampholders that shall be designed to minimize the deposit of dust on lamps and to prevent the escape of sparks, burning material, or hot metal. Each fixture shall be clearly marked to indicate the maximum wattage of the lamp that shall be permitted without exceeding an exposed surface temperature of 165°C under normal conditions of use.

29.11.2.3 **Physical Damage**

Lighting fixtures for fixed lighting shall be protected from physical damage by suitable guards or by location.

29.11.2.4 **Pendant Fixtures**

Pendant fixtures shall be suspended by threaded rigid metal conduit stems, threaded steel intermediate metal conduit stems, by chains with approved fittings, or by other approved means. For rigid stems longer than 30 cm, permanent and effective bracing against lateral displacement shall be provided at a level not more than 30 cm above the lower end of the stem, or flexibility in the form of a fitting or a flexible connector approved for the purpose shall be provided not more than 30 cm from the point of attachment to the supporting box or fitting. Where wiring between an outlet box or fitting and a pendant fixture is not enclosed in conduit, flexible cord approved for hard usage shall be used. Flexible cord shall not serve as the supporting means for a fixture.

29.11.2.5 **Supports**

Boxes, box assemblies, fittings used for support of lighting fixtures shall be approved for the purpose.

29.11.2.6 **Electric-Discharge Lamps**

Starting and control equipment for electric-discharge lamps shall comply with the requirements of item 29.7.2.

29.12 **Flexible Cords, Class 2, Divisions 1 and 2**

Flexible cords used in Class 2 locations shall comply with the following: (1) be of a type approved for extra-hard usage; (2) contain, in addition to the conductors

of the circuit, a grounding conductor; (3) be connected to terminals or to supply conductors in an approved manner; (4) be supported by clamps or by other suitable means in such a manner that there will be no tension on the terminal connection; and (5) be provided with suitable seals to prevent the entrance of dust where the flexible cord enters boxes or fittings that are required to be dust-ignition-proof.

29.13 Receptacles and Attachment Plugs

29.13.1 Class 2 Division 1

In Class 2, Division 1 locations, receptacles and attachment plugs shall be of the type providing for connection to the grounding conductor of the flexible cord and shall be approved for Class 2 locations.

29.13.2 Class 2, Division 2

In Class 2, Division 2 locations, receptacles and attachment plugs shall be of the type providing for connection to the grounding conductor of the flexible cord and shall be so designed that connection to the supply circuit cannot be made or broken while live parts are exposed.

29.14 Signaling, Alarm, Remote-Control, Communication Systems, Meters, Instruments, and Relays

29.14.1 Class 2, Division 1

In Class 2, Division 1 locations, signaling, alarm, remote-control, communication systems; meters, instruments and relays shall comply with the provisions of items 29.14.1.1 through 29.14.1.6 below:

29.14.1.1 Wiring Methods

Where accidental damage or breakdown of insulation might cause arcs, sparks, or high temperatures, the wiring method shall be rigid metal conduit, intermediate metal conduit, electrical metallic tubing, or mineral-insulated metal sheathed cable with approved termination fittings. For rigid metal conduit, intermediate metal conduit or electrical metallic tubing, the number of conductors shall be limited only by the requirement that the cross-sectional area of all conductors shall not exceed 40 percent of the area of the raceway. Where limited flexibility is desirable or where exposure to physical damage is not severe, a flexible cord approved for extra-hard usage shall be permitted.

29.14.1.2 Contacts

Switches, circuit breakers, relays, contactors, fuses, and current-breaking contacts for bells, horns, howlers, sirens, and other devices in which sparks or arcs may be produced shall be provided with enclosures approved for a Class 2 location.

Exception:

Where current-breaking contacts are immersed in oil, or where the interruption of current occurs within a chamber sealed against the entrance of dust, enclosures shall be permitted to be of the general-purpose type.

29.14.1.3 Resistors and Similar Equipment

Resistors, transformers, choke coils, rectifiers, thermionic tubes, and other heat-

generating equipment shall be provided with enclosures approved for Class 2 locations.

Exception:

Where resistors or similar equipment are immersed in oil, or enclosed in a chamber sealed against the entrance of dust, enclosures shall be permitted to be of the general-purpose type.

29.14.1.4 Rotating Machinery

Motors, generators, and other rotating electric machinery shall comply with item 29.8.1.

29.14.1.5 Combustible Electrically Conductive Dusts

Where dusts are of a combustible electrically conductive nature, all wiring and equipment shall be approved for Class 2 locations.

29.14.1.6 Metal Dusts

Where dust from magnesium, aluminum, aluminum bronze powders, or other metals of similar hazardous characteristics may be present, all apparatus and equipment shall be approved for the specific conditions.

29.14.2 Class 2, Division 2

In Class 2, Division 2 locations, signaling, alarm, remote-control, and communication systems; and meters, instruments, and relays shall comply with the provisions of items 29.14.2.1 through 29.14.2.4 below:

29.14.2.1 Contacts

Enclosures shall comply with item 29.14.1.2; or contacts shall have tight metal enclosures designed to minimize the entrance of dust, and shall have telescoping or tight fitting covers and no openings through which, after installation, sparks or burning material might escape.

Exception:

In circuits that under normal conditions do not release sufficient energy to ignite a dust layer, enclosures shall be permitted to be of the general-purpose type.

29.14.2.2 Transformers and Similar Equipment

The windings and terminal connections of transformers, choke coils, and similar equipment shall be provided with tight metal enclosures without ventilating openings.

29.14.2.3 Resistors and Similar Equipment

Resistors, resistance devices, thermionic tubes, rectifiers, and similar equipment shall comply with item 29.14.1.3.

Exception:

Enclosures for thermionic tubes, nonadjustable resistors, or rectifiers for which maximum operating temperature will not exceed 120°C shall be permitted to be of the general-purpose type.

29.14.2.4 Rotating Machinery

Motors, generators, and other rotating electric machinery shall comply with item 29.8.2.

29.15 Live Parts, Class 2, Divisions 1 and 2

Live parts shall not be exposed.

29.16 Grounding, Class 2, Divisions 1 and 2

Wiring and equipment shall be grounded in accordance with items 29.16.1 through 29.16.6 below:

29.16.1 Exposed Parts

Exposed noncurrent-carrying metal parts of equipment, such as the frames or metal exteriors of motors, fixed or portable lamps, lighting fixtures, or other utilization equipment, or cabinets, cases, and conduit shall be grounded as specified in item 9.

29.16.2 Bonding

The locknut-bushing and double-locknut type of contact shall not be depended upon for bonding purposes; but bonding jumpers with proper fittings or other approved means shall be used. Such means of bonding shall apply to all intervening raceways, fittings, boxes, enclosures, etc., between hazardous areas and the point of grounding for service equipment. Where flexible conduit is used as permitted in item 29.4, bonding jumpers with proper fittings shall be provided around such conduit.

29.16.3 Lightning Protection

Each ungrounded service conductor of a wiring system in a Class 2 location, where supplied from an ungrounded overhead electric supply system in an area where lightning disturbances are prevalent, shall be protected by a lightning protective device of a proper type. Lightning protective devices shall be connected to the service conductors on the supply side of the service disconnecting means, and shall be bonded to the raceway system at the service entrance.

29.16.4 Grounded Service Conductor Bonded to Raceway

Wiring in a Class 2 location, where supplied from a grounded alternating-current supply system in which a grounded conductor is a part of the service, shall have the grounded service conductor bonded to the raceway system and to the grounding conductor for the raceway system. The bonding connection to grounded service conductor shall be made on the supply side of the service disconnecting means.

29.16.5 Transformer Ground Bonded to Raceway

Wiring in a Class 2 location, where supplied from a grounded alternating-current supply system in which no grounded conductor is a part of the service, shall be provided with a metallic connection between the supply system ground and the service-equipment enclosure.

29.16.6 Multiple Grounds

Where it is necessary to abandon one or more grounding connections to avoid objectionable passage of current over the grounding conductors, the connection required in items 29.16.4 or 29.16.5 shall not be abandoned while any other grounding connection remains connected to the supply system.

30. CLASS 3 LOCATIONS**30.1 General**

The general rules of Section 7.0 shall apply to electric wiring and equipment in locations classified as Class 3 locations in item 27.5, except as modified by this item 30.

Equipment installed in Class 3 locations shall be able to function at full rating without developing surface temperatures high enough to cause excessive dehydration or gradual carbonization of accumulated fibers or flyings. Organic material that is carbonized or excessively dry is highly susceptible to spontaneous ignition. The maximum surface temperatures under operating conditions shall not exceed 165°C for equipment that is not subject to overloading, and 120°C for equipment (such as motors or power transformers) that may be overloaded.

30.2 Transformers and Capacitors, Class 3, Divisions 1 and 2

Transformers and capacitors shall comply with item 29.2.

30.3 Wiring Methods

Wiring methods shall comply with items 30.3.1 and 30.3.2 below:

30.3.1 Class 3, Division 1

In Class 3, Division 1 locations the wiring method shall be threaded rigid metal conduit, threaded steel intermediate metal conduit, or approved mineral-insulated metal-sheathed or metal clad cable.

30.3.1.1 Boxes and Fittings

Fittings and boxes in which taps, joints, or terminal connections are made shall: (1) be provided with telescoping or close fitting covers or other effective means to prevent the escape of sparks or burning material, and (2) shall have no openings (such as holes for attachment screws) through which, after installation, sparks or burning material might escape, or through which adjacent combustible material might be ignited.

30.3.1.2 Flexible Connections

Where flexible connections are necessary, item 29.4.1.2 shall apply.

30.3.2 Class 3, Division 2

In Class 3, Division 2 locations, the wiring method shall comply with item 30.3.1.

Exception:

In sections, compartments, or areas used solely for storage and containing no machinery, open wiring on insulator shall be permitted where conductors are run in roof spaces or are well out of reach of sources of physical damage. Protection

must be provided when conductors could be subject to physical damage.

30.4 Switches, Circuit Breakers, Motor Controllers, and Fuses, Class 3, Divisions 1 and 2

Switches, circuit breakers, motor controllers, and fuses, including pushbuttons, relays, and similar devices, shall be provided with tight metal enclosures designed to minimize entrance of fibers and flyings, and which shall: (1) be equipped with telescoping or close fitting covers or with other effective means to prevent escape of sparks or burning materials, and (2) have no openings (such as holes for attachment screws) through which, after installation, sparks or burning material might escape, or through which exterior accumulations of fibers or flyings or adjacent combustible material might be ignited.

30.5 Control Transformers and Resistors, Class 3, Divisions 1 and 2

Transformers, impedance coils, and resistors used as or in conjunction with control equipment for motors, generators, and appliances shall comply with item 29.7.

Exception:

In Class 3, Division 1 locations where these devices are in the same enclosure with switching devices of such control equipment and are used only for starting or short-time duty, the enclosure shall comply with item 30.4.

30.6 Motors and Generators

30.6.1 Class 3, Division 1

In Class 3, Division 1 locations, motors, generators, and other rotating electric machinery shall be totally enclosed nonventilated, totally enclosed pipe-ventilated, or totally enclosed fan-cooled.

Exception:

In locations where, in the judgment of the authority having jurisdiction, only moderate accumulations of lint or flyings will be likely to collect on, in, or in the vicinity of a rotating electric machine, and where such machine is readily accessible for routine cleaning and maintenance, one of the following shall be permitted:

- (1) Self-cleaning textile motors of the squirrel-cage types;
- (2) Standard open-type machines without sliding contacts, centrifugal or other types of switching mechanism, including motor overload devices; or
- (3) Standard open-type machines having such contacts, switching mechanisms, or resistance devices enclosed within tight metal housings without ventilating or other openings.

30.6.2 Class 3, Division 2

In Class 3, Division 2 locations, motors, generators, and other rotating electric machinery shall be totally enclosed non-ventilated, totally enclosed pipe-ventilated, or totally enclosed fan-cooled.

30.6.3 Types Not Permitted, Class 3, Divisions 1 and 2

Motors, generators, or other rotating electric machinery of the partially enclosed

or splash-proof type shall not be installed in Class 3 locations.

30.7 Ventilating Pipes, Class 3, Divisions 1 and 2

Ventilating pipes for motors, generators, or other rotating electric machinery, or for enclosures for electric equipment shall comply with the following: (1) lead directly to a source of clean air outside of buildings; (2) be screened at the outer ends to prevent the entrance of small animals or birds; and (3) be protected against physical damage and against rusting or other corrosive influences.

Ventilating pipes shall be sufficiently tight, including their connections, to prevent the entrance of appreciable quantities of fibers or flyings into the ventilated equipment or enclosure and to prevent the escape of sparks, flame or burning material that might ignite accumulations of fibers or flyings or combustible material in the vicinity. For metal pipes, lock seams and riveted or welded joints shall be permitted; and tight-fitting slip joints shall be permitted where some flexibility is necessary, as at connections to motors.

30.8 Utilization Equipment, Class 3, Divisions 1 and 2

30.8.1 Heaters

Electrically heated utilization equipment shall be approved for Class 3 locations.

30.8.2 Motors

Motors of motor-driven utilization equipment shall comply with item 30.6.

30.8.3 Switches, Circuit Breakers, Motor Controllers, and Fuses

Switches, circuit breakers, motor controllers, and fuses shall comply with item 30.4.

30.9 Lighting Fixtures, Class 3, Divisions 1 and 2

30.9.1 Fixed Lighting

Lighting fixtures for fixed lighting shall provide enclosures for lamps and lampholders that are designed to minimize entrance of fibers and flyings and to prevent the escape of sparks, burning material, or hot metal. Each fixture shall be clearly marked to show the maximum wattage of the lamps that shall be permitted without exceeding an exposed surface temperature of 165°C under normal conditions of use.

30.9.2 Physical Damage

A fixture that may be exposed to physical damage shall be protected by a suitable guard.

30.9.3 Pendant Fixture

Pendant fixtures shall be suspended by stems of threaded rigid metal conduit, threaded intermediate metal conduit, or threaded metal tubing of equivalent thickness. For stems longer than 30 cm, permanent and effective bracing against lateral displacement shall be provided at a level not more than 30 cm above the lower end of the stem, or flexibility in the form of a fitting or a flexible connector approved for the purpose shall be provided not more than 30 cm from the point of attachment to the supporting box or fitting.

30.9.4 Supports

Boxes, box assemblies or fittings used for the support of lighting fixtures shall be of a type approved for the purpose.

30.9.5 Portable Lamps

Portable lamps shall be equipped with handles and protected with substantial guards, and lampholders shall be of the unswitched type with no exposed metal parts and without provision for receiving attachment plugs. In all other respects, portable lamps shall comply with item 30.9.1.

30.10 Flexible Cords, Class 3, Divisions 1 and 2

Flexible cords shall comply with item 29.12.

30.11 Receptacles and Attachment Plugs, Class 3, Divisions 1 and 2

Receptacles and attachment plugs shall comply with item 29.13.2.

30.12 Signalling, Alarm, Remote-Control, and Local Loud-Speaker Intercommunication Systems, Class 3, Divisions 1 and 2

Signalling, alarm, remote-control, and local loud-speaker intercommunication systems shall comply with item 29.14.1.

30.13 Electric Cranes, Hoists, and Similar Equipment, Class 3, Divisions 1 and 2

Where installed for operation over combustible fibers or accumulations of flyings, travelling cranes and hoists for material handling, travelling cleaners for textile machinery, and similar equipment shall comply with items 30.13.1 through 30.13.4 below:

30.13.1 Power Supply

Power supply to contact conductors shall be isolated from all other systems, shall be ungrounded, and shall be equipped with an acceptable recording ground detector that will give an alarm and automatically de-energize the contact conductors in case of a fault to ground, or with an acceptable ground-fault indicator that will give a visual and audible alarm, and maintain the alarm as long as power is supplied to the system and the ground fault remains.

30.13.2 Contact Conductors

Contact conductors shall be so located or guarded as to be inaccessible to other than authorized persons and shall be protected against accidental contact with foreign objects.

30.13.3 Current Collectors

Current collectors shall be so arranged or guarded as to confine normal sparking and prevent escape of sparks or hot particles. To reduce sparking, 2 or more separate surfaces of contact shall be provided for each contact conductor. Reliable means shall be provided to keep contact conductors and current collectors free of accumulations of lint or flyings.

30.13.4 Control Equipment

Control equipment shall comply with items 30.4 through 30.5.

30.14 Storage-Battery Charging Equipment, Class 3, Divisions 1 and 2

Storage-battery charging equipment shall be located in separate rooms built or lined with substantial noncombustible materials so constructed as to adequately exclude flyings or lint and shall be well-ventilated.

30.15 Live Parts, Class 3, Divisions 1 and 2

Live parts shall not be exposed.

30.16 Grounding, Class 3, Divisions 1 and 2

Wiring and equipment shall be grounded in accordance with item 29.16.

31. HAZARDOUS (CLASSIFIED) LOCATIONS - SPECIFIC**31.1 Scope**

Items 32 through 35 cover occupancies or parts of occupancies that are or may be hazardous because of atmospheric concentrations of flammable liquids, gases, or vapors, or because of deposits or accumulations of materials that may be readily ignitable .

31.2 General

The general rules of Section 7.0 shall apply to electric wiring and equipment in occupancies within the scope of items 32 through 35, except as such rules are modified in those items. Where unusual conditions exist in a specific occupancy, the authority having jurisdiction shall judge with respect to the application of specific rules.

32. AIRCRAFT HANGARS**32.1 Definition**

An aircraft hanger is a location used for the storage or service of aircraft in which gasoline jet fuels or other volatile flammable liquids or flammable gases are used. It shall not include locations used exclusively for aircraft that have never contained such liquids or gases, or that have been drained and properly purged.

32.2 Classification of locations**32.2.1 Bellow floor level**

Any pit or depression below the level of the hanger floor shall be classified as a Class 1, Division 1 location that shall extend up to said floor level.

32.2.2 Areas not cut off or ventilated

The entire area of the hangar, including any adjacent and communicating areas not suitably cut off from the hangar, shall be classified as a Class 1, Division 2 location up to a level 45 cm above the floor.

32.2.3 Vicinity of aircraft

The area within 1.5 m horizontally from aircraft power plants or aircraft fuel tanks shall be classified as a Class 1, Division 2 location that shall extend upward from the floor to a level 1.5 m above the upper surface of wings and of engine enclosures.

32.2.4 Areas suitably cut off and ventilated

Adjacent areas in which flammable liquids or vapors are not likely to be released, such as stock rooms electrical control rooms, and other similar locations, shall not be classified as hazardous where adequately ventilated and where effectively cut off from the hangar itself by walls or partitions.

32.2 Wiring and equipment in hazardous

All wiring and equipment that is or may be installed or operated within any of the hazardous locations defined in item 32.2 shall comply with the applicable provisions of item 28. All wiring installed in or under the hangar floor shall comply with the requirements for Class 1, Division 1 hazardous locations. Where such wiring is located in vaults, pits, or ducts, adequate drainage shall be provided; and the wiring shall not be placed within the same compartment with any service other than piped compressed air.

Attachment plugs and receptacles in hazardous locations shall be approved for Class 1 locations or shall be so designed that they cannot be energized while the connections are being made or broken.

32.4 Wiring Not Within Hazardous Locations**32.4.1 Fixed wiring**

All fixed wiring in a hangar, but not within a hazardous location as defined in item 32.3, shall be installed in metallic raceways or shall be mineral-insulated metal-sheathed, shielded non-metallic sheathed, metal clad or tray cable.

Exception:

Wiring in nonhazardous locations as defined in item 32.2.4, shall be of a type recognized in the relevant Section 7.0.

32.4.2 Pendants

For pendants, flexible cord suitable for the type of service and approved for hard usage shall be used. Each cord shall include a separate grounding conductor.

32.4.3 Portable equipment

For portable utilization equipment and lamps, flexible cord suitable for the type of service and approved for extra-hard shall be used. Each cord shall include a separate grounding conductor.

32.4.4 Grounded and grounding conductors

Where a circuit supplies portables or pendants and includes an identified grounded conductor, receptacles, attachment plugs, connectors, and similar devices shall be of the polarized type, and the grounded conductor of the flexible cord shall be connected to the screw-shell of any lampholder or to the grounded terminal of any utilization equipment supplied. Acceptable means shall be provided for maintaining continuity of the grounding conductor between the fixed raceway system and the noncurrent-carrying metal portions of pendant fixtures, portable lamps, and portable utilization equipment.

32.5 Equipment Not Within Hazardous Locations**32.5.1 Arcing equipment**

In locations other than those described in item 32.3, equipment that is less than 3.0 m above wings and engine enclosures of aircraft and that may produce arcs, sparks or particles of hot metal, such as lamps and lampholders for fixed lighting, cutouts, switches, receptacles, charging panels, generators, motors, or other equipment having make-and-break or sliding contacts, shall be of the totally enclosed type or so constructed as to prevent escape of sparks or hot metal particles.

Exception:

Equipment in areas described in item 32.2.4 shall be permitted to be of the general-purpose type.

32.5.2 Lampholders

Lampholders of metal-shell, fiber-lined types shall not be used for fixed incandescent lighting.

32.5.3 Portable lamps

Portable lamps that are or may be used within a hangar shall be approved for Class 1 locations.

32.5.4 Portable equipment

Portable utilization equipment that is or may be used within a hangar shall be of a type suitable for use in Class 1, Division 2 locations.

32.6 Stanchions, Rostrums, and Docks

32.6.1 In hazardous location

Electric wiring, outlets, and equipment (including lamps) on or attached to stanchions, rostrums, or docks that are located or likely to be located in a hazardous location as defined in item 32.2.3, shall comply with the requirements for Class 1, Divisions 2 locations.

32.6.2 Not in hazardous location

Where stanchions, rostrums, or docks are not located or likely to be located in a hazardous location as defined in item 32.2.3, wiring and equipment shall comply with items 32.5 and 32.6, except that such wiring and equipment not more than 45 cm above the floor in any position shall comply with item 32.6.1. Receptacles and attachment plugs shall be of locking type that will not readily disconnect.

32.6.3 Mobile type

Mobile stanchions with electric equipment complying with item 32.6.2, shall carry at least 1 permanently affixed warning sign to read: "WARNING - KEEP 1.5 METERS CLEAR OF AIRCRAFT ENGINES AND FUEL TANK AREAS".

32.7 Sealing

Approved seals shall be provided in accordance with item 28.5. Sealing requirements specified in items 28.5.1.4 and 28.5.2.2, shall apply to horizontal as well as to vertical boundaries of the defined hazardous locations. Raceways embedded in a masonry floor or buried beneath a floor shall be considered to be within the hazardous location above the floor where any connections or extensions lead into or through locations.

32.8 Aircraft Electrical Systems

Aircraft electrical systems shall be de-energized when the aircraft is stored in a hangar, and, whenever possible, while the aircraft is undergoing maintenance.

32.9 Aircraft Battery - Charging and Equipment

Aircraft batteries shall not be charged when installed in an aircraft located inside or partially inside a hangar.

Battery charges and their control equipment shall not be located or operated within any of the hazardous areas defined in item 32.2, and shall preferably be located in a separate building or in an area such as defined in item 32.2.4. Mobile chargers shall carry at least one permanently affixed warning sign: "WARNING - KEEP 1.5 METERS CLEAR OF AIRCRAFT ENGINES AND FUEL TANK AREAS". Tables, racks, trays, and wiring shall not be located within a hazardous location.

32.10 External Power Sources for Energizing Aircraft**32.10.1 Not less than 45 cm above floor**

Aircraft energizers shall be so designed and mounted that all electric equipment and fixed wiring will be at least 45 cm above floor level and shall not be operated in hazardous location as defined in item 32.2.3.

32.10.2 Marking for mobile units

Mobile energizers shall carry at least one permanently affixed warning sign to read: "WARNING - KEEP 1.5 METERS CLEAR OF AIRCRAFT ENGINES AND FUEL TANK AREAS".

32.10.3 Cords

Flexible cords for aircraft energizers and ground support equipment shall be approved for the type of service and extra-hard usage and shall include an equipment grounding conductor.

32.11 Mobile Servicing Equipment with Electric Components**32.11.1 General**

Mobile servicing equipment (such as vacuum cleaners, air compressors, air movers, etc). having electric wiring and equipment not suitable for Class 1, Division 2 locations shall be so designed and mounted that all such fixed wiring and equipment will be at least 45 cm above the floor. Such mobile equipment shall not be operated within the hazardous location defined in item 32.2.3, and shall carry at least one permanently affixed warning sign to read: "WARNING - KEEP 1.5 METERS CLEAR OF AIRCRAFT ENGINES AND FUEL TANK AREAS".

32.11.2 Cords and connectors

Flexible cords for mobile equipment shall be suitable for the type of service and approved for extra-hard usage, and shall include and equipment grounding conductor. Attachment plugs and receptacles shall be approved for the location in which they are installed, and shall provide for connection of the grounding conductor to the raceway system.

32.11.3 Restricted use

Equipment not suitable for Class 1, Division 2 locations shall not be operated in locations where maintenance operations likely to release flammable liquids or vapors are in progress.

32.12 Grounding

All metal raceways and all noncurrent-carrying metal portions of fixed or portable equipment, regardless of voltage, shall be grounded as provided in item 9.

33. BULK-STORAGE PLANTS**33.1 Definition**

A bulk-storage plant is a location where gasoline or other volatile flammable liquids are stored in tanks having an aggregate capacity of one carload or more, and from which such products are distributed.

33.2 Classification of locations**33.2.1 General**

The extent of hazardous locations within a bulk-storage plant shall be as indicated in Table 6.

33.2.2 Adjacent locations

Office buildings, boiler rooms and similar locations, that are outside the limits of hazardous locations and are not used for handling or storage of volatile flammable liquids or containers for such liquids, shall not be classified as hazardous locations as defined in item 27.1.

33.3 Wiring and equipment within hazardous locations

All electric wiring and equipment within the hazardous locations defined in Table 6 shall comply with the applicable provisions of item 28.

Exception:

As permitted in item 33.5

33.4 Wiring and Equipment Above Hazardous Locations

All fixed wiring above hazardous locations shall be in metallic raceways or be mineral-insulated metal-sheathed, shielded non-metallic sheathed, metal clad or tray cable. Fixed equipment they may produce arcs, sparks, or particles of hot metal, such as lamps and lampholders for fixed lightings, cutouts, switches, receptacles, motors, or other equipment having make-and-break or sliding contacts, shall be of the totally enclosed type or be so constructed as to prevent escape of sparks or hot metal particles. Portable lamps or other utilization equipment and their flexible cords shall comply with the provisions of item 28 for the class of location above which they are connected or used.

33.5 Underground Wiring**33.5.1 Wiring Method**

Underground wiring shall be installed in rigid metal conduct, or where buried

under not less than 60 cm of earth, shall be permitted in rigid nonmetallic conduct or in the form of cable approved for the purpose. Where cable is used, it shall be enclosed in rigid metal conduct from the point of lowest buried cable level to the point of connection to the aboveground raceway.

33.5.2 Insulation

Conductor insulation shall comply with item 28.13.

33.5.3 Nonmetallic wiring

Where rigid nonmetallic conduct or cable with a nonmetallic sheath is used, an equipment grounding conductor shall be included to provide for electrical continuity for the raceway system and for grounding of noncurrent-carrying metal parts.

33.6 Sealing

Approved seals shall be provided in accordance with item 28.5. Sealing requirements in items 28.5.1.4 and 28.5.2.2, shall apply to horizontal as well as to vertical boundaries of the defined hazardous locations. Buried raceways under defined hazardous locations shall be considered to be within such locations.

33.7 Grounding

All metal raceways and all noncurrent-carrying metal parts of electric equipment shall be grounded as provided in item 9.

34. FINISHING PROCESSES

34.1 Definition

This item covers locations where paints, lacquers, or other flammable finishes are regularly or frequently applied by spraying, dipping, brushing, or by other means; where volatile flammable solvents or thinners are used; and where readily ignitable deposits or residues from such paints, lacquers, or finishes may occur.

For further information regarding safeguards for finishing processes, such as guarding, fire protection, posting of warning signs, and maintenance, see Section 4.7 and 4.8.

34.2 Classification of locations

Classification is with respect to the effects of an exposure to flammable vapours, and in some cases, deposits of paint spray residue.

34.2.1 General

The extent of hazardous locations about a finishing process shall be as indicated in Section 4.7.

34.2.2 Adjacent locations

Adjacent locations that are cut off from the defined hazardous locations by tight partitions without communicating openings, and within which hazardous vapors are not likely to be released, shall be classified as nonhazardous unless authority having jurisdiction judges otherwise.

34.2.3 Nonhazardous locations

Locations utilizing drying, curing, or fusion apparatus and provided with positive mechanical ventilation adequate to prevent formation of flammable concentrations of vapors, and provided with effective interlocks to de-energize all electric equipment (other than equipment approved for Class 1 locations) in case the ventilating equipment is inoperative, may be classified as nonhazardous where the authority having jurisdiction so judges.

34.3 Wiring and Equipment in Hazardous Locations**34.3.1 Wiring and Equipment - Vapours**

All electric wiring and equipment within the hazardous location (containing vapour only - not residues) shall comply with the applicable provisions of item 28.

34.3.2 Wiring and Equipment - and Vapours and Residues

Unless approved for both readily ignitable deposits and the flammable vapour locations, no electric equipment shall be installed or used where it may be subject to hazardous accumulations of readily ignitable deposits or residues, as the susceptibility to spontaneous heating and ignition of some residues may be greatly increased at temperatures above normal. Mineral-insulated metal-sheathed cable and wiring in threaded rigid metal conduit may be installed in such locations, if the explosion-proof boxes or fittings contain no taps, splices or terminal connections that may possibly become loose in service and thereby cause abnormal temperatures on external surfaces of boxes or fittings.

34.3.3 Illumination

Illumination of readily ignitable areas through panels of glass or other transparent or translucent material shall be permitted only if it complies with the following: (1) fixed lighting units are used as the source of illumination; (2) the panel effectively isolates the hazardous location from the area in which the lighting unit is located; (3) the lighting unit is approved for its specific location; (4) the panel is of a material or is so protected that breakage will be unlikely; and (5) the arrangement is such that normal accumulations of hazardous residues on the surface of the panel will not be raised to a dangerous temperature by radiation or conduction from the source of illumination.

34.3.4 Portable Equipment

Portable electric lamps or other utilization equipment shall not be used within a hazardous location during operation of the finishing process. When such lamps or utilization equipment are used during cleaning or repairing operations, they shall be of a type approved for Class 1, Group D, Division 1 locations, and all exposed metal part shall be effectively grounded.

34.3.5 Electrostatic Equipment

Electrostatic spraying or detearing equipment shall be installed and used only as provided in items 4.7.8 and 4.7.9.

34.4 Wiring and Equipment Above Hazardous Locations**34.4.1 Wiring**

All fixed wiring above the hazardous locations shall be in metal raceways or shall

be mineral-insulated metal-sheathed, shielded non-metallic sheathed, metal-clad or tray cable. Cellular metal floor raceways shall be permitted only for supplying ceiling outlets or extensions to the area below the floor of a hazardous locations, but such raceways shall have no connections leading into or through the hazardous location above the floor unless suitable seals are provided. No electric conductor shall be installed in any cell or header that contains a pipe for steam, water, air, gas, drainage, or for other than the electrical service.

34.4.2 **Equipment**

Equipment that may produce arcs, sparks, or particles of hot metal, such as lamps and lampholders for fixed lighting, cutouts, switches, receptacles, motors, or other equipment having make-and-break or sliding contacts, where installed above a hazardous location or above a location where freshly finished goods are handled, shall be of the totally enclosed type or be so constructed as to prevent escape of sparks or hot metal particles.

34.5 **Grounding**

All metal raceways and all noncurrent-carrying metal parts of fixed or portable equipment, regardless of voltage, shall be grounded as provided in item 9.

35. **GASOLINE DISPENSING AND SERVICE STATION**

35.1 **Definition**

A gasoline dispensing and service station is a location where gasoline or other volatile flammable liquids or liquefied flammable gases are transferred to the fuel tanks (including auxiliary fuel tanks) of self-propelled vehicles.

Where the authority having jurisdiction can satisfactorily determine that flammable liquids having a flash point below 60°C, such as gasoline, will not be handled, he may classify such a location as nonhazardous.

35.2 **Classification of Locations**

The extent of hazardous locations within a gasoline dispensing or service station shall be as indicated in Table 7.

35.3 **Wiring and Equipment Within Hazardous Locations**

All electric equipment and wiring within hazardous locations defined in Table 7, shall comply with the applicable provisions of item 28, except as permitted in item 35.9.

35.4 **Wiring in Spaces Above Hazardous Areas**

35.4.1 All fixed wiring above hazardous areas shall be in metallic raceways or shall be mineral-insulated metal-sheathed, shielded non-metallic sheathed, metal clad or tray cable. Cellular metal floor raceways shall be permitted to be used only for supplying ceiling outlets or extensions to the area below the floor, but such raceways shall have no connections leading into or through any hazardous area above the floor. No electrical conductor shall be installed in any cell, header, or duct which contains a pipe for any service except electrical or compressed air.

35.4.2 For pendants, flexible cord suitable for the type of service and approved for hard

usage shall be used.

- 35.4.3 When a circuit which supplies portables or pendants includes an identified grounded conductor, receptacles, attachment plugs, connectors, and similar devices shall be of polarized type, and the identified conductor of the flexible cord shall be connected to the screw-shell of any lampholder or to the identified terminal of any utilization equipment supplied.

- 35.4.4 Attachment plug receptacles in fixed position shall be located above the level of any defined hazardous area, or be approved for the location.

35.5 **Equipment Above Hazardous Locations**

35.5.1 **Arcing Equipment**

Equipment that is less than 3.5 m above the floor level and that may produce arcs, sparks, or particles of hot metal, such as cutouts, switches, charging panels, generators, motors, or other equipment (excluding receptacles, lamps and lampholders) having make-and-break or sliding contacts, shall be of the totally enclosed type or so constructed as to prevent escape of sparks or hot metal particles.

35.5.2 **Fixed Lighting**

Lamps and lampholders for fixed lighting that is located over lanes through which vehicles are commonly driven or that may otherwise be exposed to physical damage shall be located not less than 3.5 m above floor level, unless of the totally enclosed type or so constructed as to prevent escape of sparks or hot metal particles.

35.6 **Circuit Disconnects**

Each circuit leading to or through a dispensing pump shall be provided with a switch or other acceptable means to disconnect simultaneously from the source of supply all conductors of the circuit, including the grounded neutral, if any.

35.7 **Sealing**

35.7.1 **At Dispenser**

An approved seal shall be provided in each conduit run entering or leaving a dispenser or any cavities or enclosures in direct communication therewith. The sealing fitting shall be the first fitting after the conduit emerges from the earth or concrete.

35.7.2 **At Boundary**

Additional seals shall be provided in accordance with item 28.5. Items 28.5.1.4 and 28.5.2.2, shall apply to horizontal as well as to vertical boundaries of the defined hazardous locations.

35.8 **Grounding**

Metal portions of dispensing pumps, metal raceways, and all noncurrent-carrying metal parts of electric equipment, regardless of voltage, shall be grounded as provided in item 9.

35.9 **Underground Wiring**

Underground wiring shall be installed in rigid metal conduit, or, where buried

under not less than 60 cm of earth, it shall be permitted in rigid nonmetallic conduit. Where rigid nonmetallic conduit is used, an equipment grounding conductor shall be included to provide electrical continuity of the raceway system and for grounding of noncurrent-carrying metal parts.

36. ELECTRICAL SIGNS AND OUTLINE LIGHTING

36.1 Disconnect Required

Each outline lighting installation, and each sign of other than the portable type, shall be controlled by an externally operable switch or breaker which will open all ungrounded conductors.

36.1.1 In Sight of Sign

The disconnecting means shall be within sight of the sign or outline lighting which it controls.

Exception:

Signs operated by electronic or electromechanical controllers located external to the sign shall have a disconnecting means located within sight from the controller location. The disconnecting means shall disconnect the sign and the

controller from all ungrounded supply conductors and shall be so designed that no pole can be operated independently. The disconnecting means shall be permitted to be in the same enclosure with the controller. This disconnecting means shall be capable of being locked in the "open" position.

36.2 Grounding

Signs, troughs, tube terminal boxes, and other metal frames shall be grounded in the manner specified in item 9.

Exception No. 1:

Where they are insulated from ground and from other conducting surfaces and are inaccessible to unauthorized persons, they need not be grounded.

Exception No. 2:

Isolated noncurrent-carrying metal parts of outline lighting may be bonded and grounded in accordance with item 9.

36.3 Clearances

36.3.1 Vertical and Horizontal

Signs and outline system enclosures shall have not less than the vertical and horizontal clearances from open conductors specified in paragraph 6.

36.3.2 Elevation

The bottom of sign and outline lighting enclosures shall not be less than 5 m above areas accessible to vehicles.

Exception:

The bottom of such enclosures may be less than 5 m above areas accessible to vehicles where such enclosures are protected from physical damage.

37. CRANES AND HOISTS**37.1 General****37.1.1 Scope**

This item 37, covers the installation of electric equipment and wiring used in connection with cranes, monorail hoists, hoists, and all runways. For further information.

37.1.2 Clearance

The dimension of the working space in the direction of access to live parts which are likely to require examination, adjustment, servicing, or maintenance while alive shall be a minimum of 75 cm. Where controls are enclosed in cabinets the door (s) shall either open at least 90 degrees or be removable.

37.1.3 Hazardous Locations

All equipment which operates in a hazardous location shall conform to item 27.

37.2 Disconnecting Means**37.2.1 Runway Conductors Disconnecting Means**

The disconnecting means shall be readily accessible and operable from the ground, shall be arranged to be locked in the "open" position, shall open all ungrounded conductors simultaneously, and shall be placed within view of the crane or hoist and the runway contact conductors.

37.2.2 Disconnecting Means for Cranes and Monorail Hoists

A motor circuit switch or circuit breaker arranged to be locked in the "open" position shall be provided in the leads from the runway contact conductors or other power supply on all cranes and monorail hoists.

Exception:

Where the crane or monorail hoist installation meets all of the following, the disconnect shall be permitted to be omitted:

- (1) The unit is floor controlled.
- (2) The unit is within view of the power supply disconnecting means.
- (3) No fixed work platform has been provided for servicing the unit.

Where the disconnecting means is not readily accessible from the crane or monorail hoist operating station, means shall be provided at the operating station to open the power circuit to all motors of the crane or monorail hoist.

37.3 Grounding

All exposed metal parts of cranes, monorail hoists, hoists and accessories including pendant controls shall be metallically joined together into a continuous electrical conductor so that the entire crane or hoist will be grounded in accordance with paragraph 9. Moving parts, other than removable accessories or attachments, having metal-to-metal bearing surfaces shall be considered to be electrically connected to each other through the bearing surface for grounding purposes. The trolley frame and bridge frame shall be considered as electrically grounded through the bridge and trolley wheels and its respective tracks unless

local conditions, such as paint or other insulating material, prevent reliable metal-to-metal contact. In this case a separate bonding conductor shall be provided.

38. ELEVATORS

38.1 General

38.1.1 Scope

This item 38 covers the installation of electric equipment and wiring used in connection with elevators. For further information, see Section 6.7.

38.1.2 Voltage Limitations

The nominal voltage used for elevator operating control and signaling circuits, operating equipment, driving machine motors, machine brakes, and motor-generator sets shall not exceed the following:

For operating control and signaling circuits and related equipment, including door operator motors: 300 volts.

Exception:

Higher potential may be used provided the current in the system cannot exceed 8 milliamperes for alternating current or 30 milliamperes for direct current.

Driving machine motors, machine brakes, and motor-generator sets: 600 volts.

Exception: Higher potentials shall be permitted for driving motors of motor-generator sets.

38.1.3 Live Parts Enclosed

All live parts of electric apparatus in the hoistways, at the landings, or in or on the cars of elevators shall be enclosed to protect against accidental contact.

38.1.4 Disconnecting Means

Elevators shall have a single means for disconnecting all ungrounded main power supply conductors for each unit.

On single and multi-car installations where a separate power supply is used for signals or lights or other equipment (multi-car) common to the group, additional separate disconnecting means shall be provided to disconnect all such ungrounded conductors for these power supplies.

Where interconnections between control panels are necessary for operation of the system on multi-car installations that remain energized from a source other than the disconnecting means, a warning sign shall be mounted on or adjacent to the disconnecting means. The sign shall be clearly legible and shall read: "WARNING - PARTS OF THE CONTROL PANEL ARE NOT DE-ENERGIZED BY THIS SWITCH."

38.1.4.1 Type

The disconnecting means shall be an enclosed externally operable fused motor circuit switch or circuit breaker arranged to be locked in the open position. No provision shall be made to close this disconnecting means from any other part of the premises, nor shall circuit breakers be opened automatically by a fire alarm

system.

38.1.4.2 **Location**

The disconnecting means shall be located where it is readily accessible to qualified persons. Where practicable, the disconnecting means shall be located adjacent to the door of the machine room or enclosure.

38.1.4.2.1 On AC control and rheostatic controlled elevators, the disconnecting means shall be located in the vicinity of the controller. When the machine is not in the vicinity of the controller, an additional manually-operated switch shall be provided at the machine, connected in the control circuit to prevent starting.

38.1.4.2.2 On elevators with generator field control, the disconnecting means shall be located within sight of the motor starter for the driver motor of the motor generator set. When the disconnecting means is not within sight of the hoist machine, the control panel, or the motor generator set, an additional manually operated switch shall be installed adjacent to the remote equipment, connected in the control circuit to prevent starting.

38.2 **Machine Room**

38.2.1 **Guarding Equipment**

Elevator driving machines, motor-generator sets, controllers, auxiliary control equipment, and disconnecting means shall be installed in a room or enclosure set aside for that purpose. The room or enclosure shall be secured against unauthorized access.

38.2.2 **Clearance Around Control Panels**

Sufficient clear working space shall be provided around control panels to provide safe and convenient access to all live parts of the equipment necessary for maintenance and adjustment. This minimum clear working space about live parts on control panels shall not be less than specified in item 3.2.

Where control panels are not located in the same space as the drive machine, they shall be located in cabinets with doors or removable panels capable of being locked in the closed position.

38.3 **Ground**

38.3.1 **Metal Raceways Attached to Cars**

Conduct, metal-clad cable, or armored cable attached to elevator cars shall be bonded to ground metal parts of the car with which they come in contact.

38.3.2 **Electric Elevators**

For electric elevators, the frames of all motors, elevator machines, controllers, and the metal enclosures for all electric devices in or on the car or in the hoistway shall be ground.

38.3.3 **Nonelectric Elevators**

For elevators other than electric having any electric conductors attached to the car, the metal frame of the car, where normally accessible to persons, shall be grounded.

38.3.4 Inherent Ground

Equipment mounted on members of the structural metal frame of a building shall be considered to be grounded. Metal car frames supported by metal hoisting cables attached to or running over sheaves or drums of elevators machines shall be considered to be grounded where the machine is grounded in accordance with item 9.

39. ELECTRIC WELDERS**39.1 Scope**

This item covers electric arc welding, resistance welding apparatus, and other similar welding equipment that is connected to an electric supply system.

39.2 Disconnecting Means for AC Transformers and DC Rectifier ARC Welders

A disconnecting means shall be provided in the supply for each AC transformer and DC rectifier arc welder which is not equipped with a disconnect mounted as an integral part of the welder. The disconnecting means shall be a switch or circuit breaker.

39.3 Disconnecting Means for Motor-Generator ARC Welders

A disconnecting means shall be provided in the supply connection of each motor-generator arc welder.

39.4 Disconnecting Means for Resistance Welders

A switch or circuit breaker shall be provided by which each resistance welder and its control equipment can be isolated from the supply circuit. The supply circuit switch shall be permitted as the welder disconnecting means where the circuit supplies only one welder.

40. DATA PROCESSING SYSTEMS**40.1 Disconnecting Means**

In addition to any integral individual disconnect switches for components or other units of the data processing system, disconnecting means shall comply with items 40.1.1 and 40.1.2 below.

40.1.1 In Data Processing Rooms

The disconnecting means shall disconnect the ventilation system serving that room and the power to all electric equipment in the room except lighting, and shall be controlled from locations readily accessible to the operator and at designated exit doors from the data processing room.

40.1.2 In General Building Areas

The disconnecting means shall disconnect all interconnected data processing equipment in the area and shall be controlled from a location readily accessible to the operator.

40.2 Grounding

All exposed noncurrent-carrying metal parts of a data processing system shall be grounded in accordance with item 9.

41. X-RAY EQUIPMENT**41.1 General****41.1.1 Scope**

The item 41, covers all X-ray equipment operating at any frequency or voltage for industrial or other nonmedical or nondental use.

Nothing in this item shall be construed as specifying safeguards against the useful beam or stray X-ray radiation.

41.1.2 Hazardous Locations

Unless approved for the location, X-ray and a related equipment shall not be installed or operated in hazardous locations.

41.1.3 Disconnecting Means

A disconnecting means shall be provided in the supply circuit. the disconnecting means shall be operable from a location readily accessible from the X-ray control. For equipment connected to a 120 volt branch circuit of 30 amperes or less, a grounding-type attachment plug cap and receptacle of proper rating shall be permitted to serve as a disconnecting means.

41.2 Control**41.2.1 Industrial Laboratory Equipment****41.2.1.1 Radiographic and Fluoroscopic Types**

All radiographic and fluoroscopic-type equipment shall be effectively enclosed or shall have interlocks that de-energize the equipment automatically to prevent ready access to live current-carrying parts.

41.2.1.2 Diffraction and Irradiation Types

Diffraction and irradiation type equipment shall be provided with a positive means to indicate when it is energized. The indicator shall be a pilot light, readable meter deflection, or equivalent means.

Exception:

Equipment or installations effectively enclosed or provided with interlocks to prevent access to live current-carrying parts during operation.

41.2.2 Independent Control

Where more than one piece of equipment is operated from the same high-voltage circuit, each piece or each group of equipment as a unit shall be provided with a high-voltage switch or equivalent disconnecting means. This disconnecting means shall be constructed, enclosed, or located so as to avoid contact by persons with its live parts.

41.3 Guarding and Grounding**41.3.1 General****41.3.1.1 High-Voltage Parts**

All high-voltage parts, including X-ray tubes, shall be mounted within grounded enclosures. Air, oil, gas, or other suitable insulating media shall be used to insulate the high voltage from the grounded enclosure. The connection from the high-voltage equipment to X-ray tubes and other high-voltage components shall be made with high-voltage shielded cables.

41.3.1.2 Low-Voltage Cables

Low-voltage cables connecting to oil-filled that units are not completely sealed, such as transformers, condensers, oil coolers, and high-voltage switches, shall have insulation of the oil-resistant type.

41.4 Grounding

Noncurrent-carrying metal parts of X-ray and associated equipment (controls, tables, X-ray tube supports, transformer tanks, shielded cables, X-ray tube heads, etc.), shall be grounded in the manner specified in item 9. Portable and mobile equipment shall be provided with an approved grounding-type attachment plug cap.

Exception:

Battery-operated equipment.

42. INDUCTION AND DIELECTRIC HEATING EQUIPMENT**42.1 General****42.1.1 Scope**

This item 42, covers the construction and installation of induction and dielectric heating equipment and accessories for industrial and scientific applications but not for medical or dental applications, or for appliances.

42.1.2 Definitions**Dielectric Heating**

Dielectric heating is the heating of a nominally insulating material due to its own dielectric losses when the material is placed in a varying electric field.

Heating Equipment

The term "heating equipment" as used in this item includes any equipment used for heating purposes whose heat is generated by induction or dielectric methods.

Induction Heating

Induction heating is the heating of a nominally conductive material due to its own $I^2 R$ losses when the material is placed in a varying electromagnetic field.

42.1.3 Hazardous Locations

Induction and dielectric heating equipment shall not be installed in hazardous

locations, unless the equipment and wiring are designed and approved for the hazardous locations.

42.1.4 **Disconnecting Means**

A readily accessible disconnecting means shall be provided by which each heating equipment can be isolated from its supply circuit. The supply circuit disconnecting means shall be permitted for disconnecting the heating equipment where the circuit supplies only one equipment.

42.1.5 **Remote Control**

42.1.5.1 **Selector Switch**

Where remote controls are used for supplying power, a selector switch shall be provided and interlocked to provide power from only one control point at a time.

42.1.5.2 **Foot Switches**

Switches operated by foot pressure shall be provided with a shield over the contact button to avoid accidental closing of a switch.

42.2 **Guarding, Grounding and Labelling**

42.2.1 **Enclosures**

The converting apparatus (including the DC line) and high-frequency electric circuits (excluding the output circuits and remote-control circuits) shall be completely contained within an enclosure or enclosures of noncombustible material.

42.2.2 **Panel Controls**

All panel controls shall be of dead-front construction.

42.2.3 **Access to Internal Equipment**

Doors or detachable panels shall be employed for internal access. Where doors are used giving access to voltages from 500 to 1000 volts AC or DC, either door locks shall be provided or interlocking shall be installed. Where doors are used giving access to voltages of over 1000 volts AC or DC, either mechanical lockouts with a disconnecting means to prevent access until voltage is removed from the cubicle, or both door interlocking and mechanical door locks shall be provided. Detachable panels not normally used for access to such parts shall be fastened in a manner that will make them inconvenient to remove.

42.2.4 **Warning Labels**

"Danger" labels shall be attached on the equipment, and shall be plainly visible even when doors are open or panels are removed from compartments containing voltages of over 250 volts AC or DC.

42.2.5 **Capacitors**

Where capacitors in excess of 0.1 microfarad are used in DC circuits, either as rectifier filter components or suppressors, etc., having circuit voltages of over 240 volts to ground, bleeder resistors or grounding switches shall be used as grounding devices. The time of discharge shall be in accordance with item 26.2.1.

Where capacitors are individually switched out of a circuit a bleeder resistor or

automatic switch shall be used as a discharge means.

Where auxiliary rectifiers are used with filter capacitors in the output for bias supplies, tubes keyers, etc., bleeder resistors shall be used even though the DC voltage may not exceed 240 volts.

42.2.6 **Work Applicator Shielding**

Protective cages or adequate shielding shall be used to guard work applicators other than induction heating coils. Induction heating coils shall be permitted to be protected by insulation and/or refractory materials. Interlock switches shall be used on all hinged access doors, sliding panels, or other easy means of access to the applicator. All interlock switches shall be connected in such a manner as to remove all power from the applicator when any one of the access doors or panels is open. Interlocks on access doors or panels shall not be required if the applicator is an induction heating coil at DC ground potential or operating at less than 150 volts AC.

42.2.7 **Grounding and Bonding**

Grounding and/or inter-unit bonding shall be used wherever required for circuit operation, for limiting to a safe value radio frequency potentials between all exposed noncurrent-carrying parts of the equipment and earth ground, between all equipment parts and surrounding objects, and between such objects and earth ground. Such grounding and bonding shall be installed in accordance with item 9.

43. **ELECTROLYTIC CELLS**

43.1 **Scope**

The provisions of this item 43, apply to the installation of the electrical components and accessory equipment of electrolytic cells, electrolytic cell lines and process power supply for the production of aluminum, cadmium, chlorine, copper, fluorine, hydrogen peroxide, magnesium, sodium, sodium chlorate and zinc.

Not covered by this item are cells used as a source of electric energy and for electroplating processes and cells used for the production of hydrogen.

43.2 **Definitions**

Cell Line

An assembly of electrically interconnected electrolytic cells supplied by a source of direct-current power.

Cell Line Attachments and Auxiliary Equipment

As applied to item 43, cell line attachments and auxiliary equipment include, but are not limited to: auxiliary tanks; process piping; duct work; structural supports; exposed cell line conductors; conduits and other raceways; pumps, positioning equipment and cell cutout or by-pass electrical devices. Auxiliary equipment includes tools, welding machine, crucibles, and other portable equipment used for operation and maintenance within the electrolytic cell line working zone.

In the cell line working zone, auxiliary equipment includes the exposed

conductive surfaces of ungrounded cranes and crane-mounted cell-servicing equipment.

Electrolytic Cell

A receptacle or vessel in which electrochemical reactions are caused by applying electrical energy for the purpose of refining or producing usable materials.

Electrolytic Cell Line Working Zone

The cell line working zone is the space envelope wherein operation or maintenance is normally performed on or in the vicinity of exposed energized surfaces of electrolytic cell lines or their attachments.

43.3 Cell Line Working Zone

43.3.1 The space envelope of the cell line working zone shall encompass any space:

Within 2.5 m above energized surfaces of electrolytic cell lines or their energized attachments.

Below energized surfaces of electrolytic cell lines or their energized attachments, provided the head room in the space beneath is less than 2.5 m.

Within 1.1 m horizontally from energized surfaces of electrolytic cell lines or their energized attachments or from the space envelope described in item 43.3.1.

43.3.2 The cell line working zone shall not be required to extend through or beyond walls, floors, roofs, partitions, barriers, or the like.

43.4 DC Cell Line Process Power Supply.

43.4.1 The DC cell line process power supply conductors shall not be required to be grounded.

43.4.2 All metal enclosures of DC cell line process power supply apparatus operating at a power supply potential between terminals of over 50 volts shall be grounded through protective relaying equipment, or by a grounding conductor or ampacity equal to 200 amp minimum or a 70 sq mm copper conductor.

43.4.3 The grounding connections required by item 43.4.2 shall be installed in accordance with items 9.8.2, 9.8.3, 9.8.5 through 9.8.7.

43.5 Disconnecting Means

43.5.1 Where more than one DC cell line process supply serves the same cell line, a disconnecting means shall be provided on the cell line circuit side of each power supply to disconnect it from the cell line circuit.

43.5.2 Removable links or removable conductors shall be permitted to be used as the disconnecting means.

43.6 Grounding

For equipment, apparatus and structural components which are required to be grounded by provisions of this item 43, the provisions of item 9 shall apply.

43.7 Fixed and Portable Electrical Equipment

43.7.1 AC system supplying fixed and portable electrical equipment within the cell line working zone shall not be required to be rounded.

43.7.2 Exposed conductive surfaces, such as electrical equipment housings, cabinets, boxes, motors, raceways and the like that are within the cell line working zone shall not be required to be ground.

43.7.3 Bonding of fixed electrical equipment to the energized conductive surface of the cell line, its attachments or auxiliaries, shall be permitted. Where fixed electrical equipment is mounted on an energized conductive surface it shall be bonded to that surface.

43.8 **Portable Electrical Equipment**

43.8.1 The frames and enclosures of portable electrical equipment used within the cell line working zone shall not be grounded.

Exception No. 1:

Where the cell line circuit voltage does not exceed 200 volts DC these frames and enclosures shall be permitted to be grounded.

Exception No. 2:

These frames in exception No. 1 and enclosures shall be permitted to be grounded where guarded.

43.8.2 Electrically powered, hand-held, cord-connected portable equipment with ungrounded frames or enclosures used within the cell line working zone shall be connected to receptacle circuits having only ungrounded conductors such as a branch circuit supplied by an isolating transformer with an ungrounded secondary.

Exception:

Where frames and enclosures of such equipment are grounded as permitted under Exception No. 1 of item 43.8.1.

43.8.3 Ungrounded portable electrical equipment shall be distinctively marked and shall employ plugs and receptacles of a configuration which prevents connection of this equipment to grounding receptacles and which prevents inadvertent interchange of ungrounded and grounded portable electrical equipments.

43.9 **Power Supply Circuits and Receptacles for Portable Electrical Equipment**

43.9.1 Circuits supplying power to ungrounded receptacles for hand-held, cord-connected equipment shall be electrically isolated from any distribution system supplying areas other than the cell line working zone and shall be ungrounded. Power for these circuits shall be supplied through isolating transformers. Primaries of such transformers shall operate at not more than 600 between conductors and shall be provided with proper overcurrent protection. The secondary voltage of such transformers shall not exceed 300 volts between conductors, and all circuits supplied from such secondaries shall be ungrounded and shall have an approved overcurrent device of proper rating in each conductor.

43.9.2 Receptacles and their mating plugs for ungrounded equipment shall not have provision for a grounding conductor and shall be of a configuration which prevent their use for equipment required to be grounded.

43.9.3 Receptacles on circuits supplied by an isolating transformer with an ungrounded secondary shall be a distinctive configuration, distinctively marked, and shall not

be used in any other location in the plant.

43.10 Auxiliary Nonelectric Connections

Auxiliary nonelectric connections, such as air hoses, water hoses, and the like, to an electrolytic cell, its attachments, or auxiliary equipment shall not have continuous conductive reinforcing wire, armor, braids and the like. Hoses shall be of a nonconductive material.

43.11 Cranes and Hoists

43.11.1 The conductive surfaces of cranes and hoists that enter the cell line working zone shall not be required to be grounded. The portion of an overhead crane or hoist which contacts an energized electrolytic cell or energized attachments shall be insulated from ground.

43.11.2 Remote crane or hoist controls which may introduce hazardous electrical conditions into the cell line working zone shall employ one or more of the following systems.

Insulated and ungrounded control circuit in accordance with item 43.9.1.

Nonconductive rope operator.

Pendant pushbutton with nonconductive supporting means and having nonconductive surfaces or ungrounded exposed conductive surfaces.

Radio for communication.

43.12 Enclosures

General-purpose electrical equipment enclosures shall be permitted where a natural draft ventilation system prevents the accumulation of gases.

44. ELECTRICALLY DRIVEN OR CONTROLLED IRRIGATION MACHINE

44.1 Scope

The provisions of this item 44, apply to electrically driven or controlled irrigation machines.

44.2 Definition

Irrigation Machines

An irrigation machine is an electrically driven or controlled machine, with 1 or more motors, not hand portable, and used primarily to transport and distribute water.

44.3 Ground

The following equipment shall be grounded:

All electrical equipment on the irrigation machine.

All electrical equipment associated with the irrigation machine.

Metallic junction boxes and enclosures.

Control panels or control equipment that supply or control electrical equipment to their irrigation machine.

Exception:

Grounding shall not be required on machines where all of the following provisions are met:

- (1) The machine is electrically controlled but not electrically driven.
- (2) The control voltage is 30 volts or less.
- (3) The control or signal circuits are current limit.

44.4 Methods of Grounding

Machines which require grounding shall have a noncurrent-carrying equipment grounding conductor provided as an integral part of each cord, cable or raceway. This grounding conductor shall be equal in size of the supply conductors.

44.5 Bonding

Where electrical grounding is required on an irrigation machine, the metallic structure of the machine, metallic conduct or metallic-sheath of cable shall be bonded to the grounding conductor. Metal-to-metal contact with a part which is bonded to the grounding conductor and the noncurrent-carrying parts of the machine shall be considered as an acceptable bonding path.

44.6 Energy from more than 1 source

Equipment within an enclosure receiving electrical energy from more than 1 source shall not be required to have a disconnecting means for the additional source, providing that its voltage is 30 volts or less.

44.7 Disconnecting Means**44.7.1 Main Disconnecting Means**

The main disconnecting means for the machine shall be located at the point of connection of electrical power to the machine and shall be readily accessible and capable of being locked in the "open" position. This disconnecting means shall have the same horsepower and current ratings as required for the main controller.

44.7.2 Disconnecting Means for Individual Motors and Controllers

A disconnecting means shall be provided for each motor and controller. The disconnecting means shall not be required to be readily accessible.

45. EMERGENCY SYSTEM**45.1 Scope**

The provisions of this item 45, apply to the installation, operation, and maintenance of circuits, systems, and equipment intended to supply illumination and power in the event of failure of the normal supply essential for safety.

Emergency systems may provide power for such functions as essential refrigeration, operation of mechanical breathing apparatus, ventilation when essential to maintain life, fire alarm systems, fire pumps, industrial processes where current interruption would produce serious hazards, public address systems, and similar functions.

45.2 Tests and Maintenance

45.2.1 Systems shall be tested periodically on a schedule acceptable to the authority having jurisdiction to assure their maintenance in proper operating condition.

45.2.2 Where battery systems or unit equipment is involved, including batteries used for starting or ignition in auxiliary engines, the authority having jurisdiction shall require periodic maintenance.

45.2.3 A written record shall be kept of such tests and maintenance, as required by the concerned authorities.

45.2.4 Means for testing any emergency lighting or power system under load shall be provided at the location of the generator, transfer switch, central battery location, or lother location satisfactory to the enforcing authority.

45.3 Emergency Illumination

Emergency illumination shall include all required exit lights and all other lights specified as necessary to provide sufficient illumination.

Emergency lighting systems shall be so designed and installed that the failure of any individual lighting element, such as the burning out of a light bulb, cannot leave any space in total darkness.

45.4 Switch Location

All manual switches for controlling emergency circuits shall be in locations convenient to authorized persons responsible for their actuation.

45.5 Accessibility

The branch circuit overcurrent devices in emergency circuits shall be accessible to authorized persons only.

46. COMMUNICATION CIRCUITS**46.1 Scope**

This item 46, covers telephone, telegraph (except radio), district messenger, outside wiring for fire alarm and burglar alarms, and similar central station systems; and telephone systems not connected to a central station system but using similar types of equipment, methods of installation, and maintenance.

46.2 Separation from Other Conductors**46.2.1 Open Conductors**

Conductors shall be separated at least 5 cm from conductors of any 120 volt or greater light or power circuits.

Exception No. 1:

Where the light or power circuit conductors are in a raceway or in metal-sheathed, metal-clad, or nonmetallic-sheathed cables.

Exception No. 2:

Where the conductors are permanently separated from the conductors of the other circuit by a continuous and firmly fixed nonconductor, such as porcelain tubes or

flexible tubing, in addition to the insulation on the wire.

46.2.2 **In Raceway and Boxes**

Communication conductors shall not be placed in any raceway, compartment, outlet box, junction box, or similar fitting with conductors of light or power circuits.

Exception No. 1:

Where the conductors of the different systems are separated by a partition.

Exception No. 2:

Conductors in outlet boxes, junction boxes, or similar fittings or compartments where such conductors are introduced solely for power supply to communication equipment or for connection to remote-control equipment.

46.2.3 **In Shafts**

Conductors run in the same shaft with conductors of light or power shall be separated from light or power conductors by not less than 5 cm.

Exception No. 1:

Where the conductors of either system are encased in noncombustible tubing.

Exception No. 2:

Where the light or power conductors are in a raceway, or in metal-sheathed, metal-clad, or nonmetallic sheathed cables.

46.3 **Overhead Conductors**

Overhead conductors entering buildings shall comply with items 46.3.1 and 46.3.2 below.

46.3.1 **On Poles**

Where communication conductors and light or power conductors are supported by the same pole, the following conditions shall be met:

Relative Location

Where practicable, the communications conductors shall be located below the light or power conductors.

Attachement to Crossarms

Conductors shall not be attached to a crossarm that carries light or power conductors.

Climbing Space

The climbing space through communication conductors shall comply with the requirements of item 6.7.2.

46.3.2 **On Roofs**

Conductors passing over buildings shall be kept at least 2.5 meters above any roof that may be readily walked upon.

46.4 Lighting Conductors

Where practicable, a separation of at least 2 m shall be maintained between open conductors of communication systems on buildings and lightning conductors.

46.5 Underground Circuit Entering Buildings

Underground conductors of communication circuits in a duct, handhole, or manhole containing electric light or power conductors shall be in a section separated from such conductors by means of brick, concrete, or tile partitions.

46.6 Grounding

Equipment shall be grounded in accordance with the requirements of item 9 and as specified in item 46.6.1 below.

46.6.1 Cable sheath

Where exposed to contact with electric light or power conductors, the metal sheath of aerial cables entering buildings shall be rounded or shall be interrupted close to the entrance to the buildings by an insulating joint or equivalent device.